THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
MAIN OFFICES:
114 LIBERTY STREET, NEW YORK.
BRANCH OFFICES:
PHILADELPHIA: Real Estate Trust Bldg.
CHICAGO: 1140 Monadnock Block.
CLEVELAND: Cuyahoga Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Canada, Cuba and Mexico...$3.00 a year.
Foreign subscription ....$6.00 a year.
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGES OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to September, 1904, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgement of assistance rendered by subscribers in the securing of new orders a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1907, by the McGraw Publishing Co.

During 1906 THE ENGINEERING RECORD circulated 677,000 copies, an average of 13,019 copies per week. Of this issue 13,250 copies are printed.

TABLE OF LEADING ARTICLES.

The Fatigue of Concrete.......... 29
The New York Rapid Transit Problem.......... 29
Fine Emergency Work.......... 30
The Question of Skilled Labor.......... 30
Steel Rails.......... 31
The Reinforced Concrete Reservoir at Waltham, Mass. (Illustrated).......... 32
The Anchor Pier Towers of the Quebec Bridge. (Illustrated).......... 34
The Second Bergen Hill Tunnel of the Lackawanna R. R. (Illustrated).......... 36
A Steel Clock Tower. (Illustrated).......... 38
Some Problems Connected with Deep Mining in the Lake Superior Copper District.......... 38
Heating System of the Kingsland Shops of the Delaware, Lackawanna & Western R. R. (Illustrated). 41
The Artistic Treatment of Concrete.......... 43
The Metropolitan Garage. (Illustrated).......... 45
Sewerage and Drainage in Johannesburg, Transvaal. (Illustrated).......... 46
Condensation Water Intake and Tower Foundations, New Waterside Station, New York Edison Co. (Illustrated).......... 47
The Keyser Building, Baltimore. (Illustrated).......... 49
The George's Creek Viaduct, Southern Ry. (Illustrated).......... 50
The Tower of the Metropolitan Life Building, New York. (Illustrated).......... 51
Progress of the Canalization of the Ohio River. (Illustrated).......... 52
The Development of Treated Wood Block Pavements in the United States. (Illustrated).......... 52
The Design of Saw-Tooth Roofs. (Illustrated).......... 53
A Fireproof Ferryboat.......... 54
Indoor and Outdoor Railway Lighting by Gas.......... 54
Reinforced Concrete Beams.......... 56
Reservoir Troubles.......... 56

The Fatigue of Concrete.

The phenomena of fatigue of structural materials are complicated. They depend upon the degree of stress applied and the molecular construction of the material about which exceedingly little is known. If the material is to some degree plastic or, in other words, not truly elastic, fatigue may mean one thing, but quite another thing if the material is as nearly perfectly elastic as structural steel. In the latter case repeated applications of stresses at short intervals, if those stresses are tension or shearing, will produce fatigue above the elastic limit. It may be that the elasticity of even such material is not sufficiently near perfect to prevent indefinitely small permanent relative movements of molecules even below the elastic limit under certain conditions, the continued accumulation of which ultimately produces failure. Although this is a reasonable hypothesis, well defined data to establish it are still lacking. It is possible that so-called truly elastic materials thus suffer fatigue in essentially the same manner as those less elastic or to some degree plastic.

It has been well established for a considerable number of years that such materials as concrete, timber and some natural stones behave under stress in a partially plastic manner, i. e., they exhibit permanent distortions under comparatively small loads, and permanent displacement of molecules increasing with time under a constant load substantially below the ultimate. The fatigue of this class of materials is far more marked than that of materials ordinarily considered truly elastic, although, as already indicated, the difference may be one of degree only. In this connection, however, there is one consideration too important to be ignored in the present condition of empirical knowledge in this field of investigation. As far as fatigue investigations have been made in such elastic materials as structural steel, it is not clear that fatigue exists under compression; or to put it correctly, perhaps such fatigue has not yet been established, while it has been unquestionably established for concrete, if not for timber, and probably for some natural stones. Whether this possible difference between the two groups of materials in respect to fatigue under compression will be established or removed will depend upon further investigations.

An interesting paper, and one containing many valuable experimental results, on "The Fatigue of Concrete" by Prof. J. L. Van Ornum, has been published in the "Proceedings" of the American Society of Civil Engineers for December, 1906. The tests given by him are those of compression and bending of concrete blocks and reinforced beams, respectively; the concrete being of a 1:3:5 mixture and at the ages of one month, six months and one year. His experimental results exhibit the usual irregularities and variations characteristic of concrete, but fatigue is just as conclusively disclosed as in the case of metals or other materials. Indeed, it should be stated that the same author made an earlier contribution to the "Transactions" of the society on this general subject about three years ago.

Stating the results briefly the second paper by Mr. Van Ornum shows that concrete will suffer fatigue under compression or bending loads exceeding about half the ultimate, the number of repetitions required to produce failure depending upon the intensity of stress, the greater the latter the less the number of repetitions required, in accordance with the general law of fatigue. It would have been in some respects more satisfactory if a mixture equivalent to 1:2:4 had been used in the reinforced beams agreeably to the best present practice in that line of engineering construction, although there is little or no room to doubt that the general character of the results would remain the same.

Mr. Van Ornum finds the usual permanent distortion with both the concrete blocks and beams that is invariably disclosed in cement and concrete tests. These permanent distortions have a most important bearing on the observed fatigue, especially in so heterogeneous a material as concrete or any other building product in which cement is the binding agent. The nature of any Portland cement product is such that even approximate uniformity of resistance will not be found throughout the volume of any member being tested. The accumulating distortions finally resulting in failure will consequently have greater enhanced values. Coupling this fact with the less elastic character of concrete it is not surprising to find the gradually progressing, though irregular, failure exhibited in the tests cited by Mr. Van Ornum. He forcefully observes that these fatigue tests indicate in connection with the known irregular experimental results of concrete when tested in the ordinary manner, that at the extreme limits of application of his results no factor of safety less than three should be used, and obviously in ordinary design work a much greater value than that should be employed.

These results should be taken only as an introduction to the general subject of the fatigue of reinforced concrete. In fact inasmuch as steel was used only on the tension side of the beams tested, the results, strictly speaking, relate not to the fatigue of reinforced concrete, but to plain concrete only. The subject of the fatigue of concrete under compression when supported by surrounding steel, as in the best type of concrete-steel columns now being built, has not yet been touched experimentally, except possibly in private tests made for one company. It is highly probable that concrete in compression and so supported will be fatigued far less than in an unsupported condition, just as it will carry a much greater load per square inch. In such a case the lateral strains of the concrete are largely prevented, and there can be no yielding of the concrete in the direction of the loading without the same amount of yielding of the steel, thus radically changing the conditions of fatigue.

It is of practical significance that the tests by Mr. Van Ornum constitute additional strong empirical evidence against the parabolic or other similar law of distribution of stress in the normal section of a loaded beam, and confirm the gradually prevailing practice of adopting the straight line law of the common theory of flexure for the actual design of beams.

The New York Rapid Transit Problem.

It is the invariable rule in planning transportation facilities that the outcome is congestion in a new spot. It seems to be almost without the powers of human kind in our country and generation to build for even the near future. The forgotten factor in design is that the modern city grows not in any ratio depending upon the general or local birthrate, but according to an unknown and unknowable law of aggregation. The population of the next decade is altogether likely to be immensely greater than any ordinary calculation would indicate, and the necessities of transportation, which is another thing undervalued, increase not merely as the population, but perhaps as the square of the population. It is New York's misfortune that the lines of transportation take but one main direction. The natural barriers of water, although bridged or tunneled, still form an obstacle to the free circulation of people that cannot be overcome. The present subway, even though it had an immediate rush of travel that sent it into a state of chronic congestion, produced only a slight and temporary effect on the traffic above ground. It would hardly be possible to build another subway fast enough to keep pace with the increase in travel. Even two built simultaneously would hardly give adequate relief. This is hardly a matter of guesswork. There are now practically five routes uptown beside the surface lines, which are not to be counted for the moment save as they may carry enough through passengers to make up for the junctions between elevated lines that lessen the facilities far uptown. The surface cars, moreover, are on every available avenue and are already gorged beyond any chance of giving material aid.

Does anybody think that New York passenger traffic will not increase 20 per cent. in the next four or five years? That is, a subway started to-morrow would hardly be completed in time to catch up, and if the two projected ones on the East Side were also started simultaneously, they would barely suffice to relieve the situation for four or five years. In point of fact the present increase of population, not by birth but by agglomeration, adds to the passenger traffic a disproportionately large amount, so that the case is worse rather than better than here presented. As to possible remedies, time is an all important consideration. There are three courses open. One can build subways under the ground or viaducts or elevated roads. The first named must be improved in ventilation to be satisfactory. Well planned and executed as the present subway was in most particulars, it has been bad in its ventilation and heat. The viaduct running along private property except on street crossings is, of course, the best system from the passenger's viewpoint, but its cost is believed, by those who have studied it carefully, to make it impracticable. Failing this there is something to be said for adding complete express tracks to the elevated roads on a plan already before the public. The main point is to start at once enough remedial measures to give rapid transit facilities a chance to get abreast of the requirements. The two proposed subways and the elevated express tracks all combined are barely enough to accomplish this on the East Side, and any delay in initiating the work means more trouble brewing. If done promptly, there will be barely time for a breathing spell in which to plan the necessary works for the future. The chief danger is that of delay in immediate action. Public bodies move slowly and with inordinate friction, and they must therefore be started up long ahead of time.

Fine Emergency Work.

Unexpected emergencies, calling for great and continued exertion, prove beyond question whether the personnel of a company is well trained and faithful. The San Francisco catastrophe of last April was a case of this sort, and the way the employes of the gas company under Mr. E. C. Jones met it is a story of hard work and well-directed ability to which only a Kipling can do full justice. Mr. Jones himself has told it after a fashion in a paper read before the Pacific Coast Gas Association, but it is not a good story because his own part is left out. This journal cannot fill in the gaps in his narrative; in fact, if it were not for information from other sources, the number and extent of the gaps would be but vaguely appreciated. Still it is worth while putting on record something, however incomplete, about one of the most creditable instances of executive engineering during the old year.

It is hardly necessary to point out that gas and air cannot be mixed with safety, for there comes a time when the mixture becomes an explosive and acts in a most inconsiderate way, as shown by the occasional ascension of manhole covers, blown skyward by explosions of air and gas that has leaked into subways and sewers. If air enters a gas main there may eventually be places along its line where the explosive mixture is formed, and it is not improbable that these mixtures may become fired. Just what fires them it is hard to say, but there are too many instances of such explosions for their occurrence to be denied. It is therefore apparent that a system of gas mains, with its street mains, services and house piping, has just as many elements of inherent danger as an electric lighting system. In San Francisco last April there were four gas works and 566 miles of street mains in use. When the first earthquake shocks tore things apart, the men in charge of the gas company's plants recognized that there was likely to be a condition of great danger, due not only to the escaping gas, but also to the inability to light the streets properly at night. Accordingly they went to work, regardless of all but the most pressing needs of their own families, to bring order out of the chaos into which the works were thrown. Toiling without intermission for nine days, they finally succeeded in getting the street mains in the unburned district repaired ready for use, so that long before the house piping had been tested, the company was ready to begin business.

To understand what this achievement amounted to, it is necessary to know something about the conditions which faced the company after the shocks on the morning of April 18. One of the gas works was very badly damaged, and although the inlet and outlet valves at the holders were at once closed by the men in charge, it was impossible on account of the injury to the plant to save the gas in more than one of the holders. At the other gas works the damage was not so great, and these plants were soon in a condition to continue production. The entire system of mains was shut off, however, and all possible measures were taken to get the street pipes into condition for promptly resuming service. The high-pressure steel line connecting two of the plants was tested and found to be tight, and within three hours of the time of the first shock, the company had its works partly patched up and was organizing its street gangs. At that time the fire which later swept a large part of the city had not assumed great proportions, the injury to the water-works mains was not known, and the extent of the disaster was unappreciated. As the fire swept forward and backward and the full measure of the results of the earthquake became evident, the men buckled down to their work, and instead of losing heart, toiled all the harder at their part of the task of reconstruction. It was not a mere case of hard work, for it was necessary to get food for the men from the bread line, and in many cases to furnish shelter for them while resting, so that the difficulties were comparable with those of an army in the field.

The actual work to be done called for much care in its supervision, for it had not progressed far before it was evident that the first great problem was to sever the connections between the street mains in the burned and unburned parts of the city. These pipes had been laid by four companies and were interconnected, but one system having valves which enabled it to be cut off from the others. It was necessary to sever every main between the districts, for if one had been left connected it would have fed gas into the burned district, with disastrous results. A 30-in. main was eventually repaired to act as a feeder. There had been 21 explosions within it, in most cases at a line drip or cross, and at these places the street had been blown up, leaving craters 12 ft. wide and 30 ft. long in some cases. In one place the earthquake had caused a settlement of 2 ft. and pulled the pipe apart 18 in. In many places the water mains had broken with the gas mains, and the latter had filled with water. In the pits that had been opened by the explosions, the sanitary gangs had thrown dead animals and covered them with sand, so that repairs were impossible until the carcasses had been cremated. After the mains had been patched up, air was purged from them, and this task was done so well that there was not an accident from the time the work began until the mains were filled with gas ready to begin supplying consumers.

Many readers of this journal have probably had some experience of the delays incident to repairing house piping and getting the service resumed. The problem facing the company was to deliver gas to 38,000 consumers along 400 miles of mains as expeditiously as possible. Owing to the probability of damage by earthquake to the piping in most buildings, every service had been shut off at the meter before gas was turned into the mains. It was, of course, impracticable to subject the piping in each house to an air test, not only on account of the expense, but also owing to the delay. Accordingly one house after another was visited by competent men and the gas turned on. Each meter had a test dial to indicate any small leakage; if the hand on this dial remained stationary the gas was left on, and if a leakage was shown, the supply was shut off again and the householder was warned of the dangerous condition and told to have the trouble remedied by a fitter. It took fourteen days to get the consumers connected up by this plan, while the usual method would have taken months. What the system meant to the people of the city can be appreciated from the fact that after the earthquake all their cooking had been done in the streets, for the chimneys were so generally injured that no fires were permitted in the houses. The resumption of gas service enabled cooking to be done by gas stoves in the houses and the streets and buildings could again be lighted three weeks after the first shocks occurred. All this was done under the most trying conditions, when the men were burdened by personal losses and often by great sorrows, and it stands out as a fine example of the esprit-de-corps which is possible with a well-managed public-service corporation.

The Question of Skilled Labor.

We are at present, perhaps, near the crest of a period of unequalled industrial activity and widespread prosperity. The manufacturer finds himself daily confronted with the difficulty in getting suitable workmen for any but the roughest tasks. Of course the old skilled craftsman is almost a creature of another age, so far as the large needs of industry are concerned. The difficulty has at present taken on a yet more serious turn in that it is most troublesome to get even the partially practiced workmen necessary under modern conditions. Twentieth century American methods carry with them this internal danger that by restricting the scope of a workman's activity to one or a few operations, the general grade of labor will deteriorate to a very serious degree. The cry of manual labor as against machine work is a very old one and its general foolishness has been pretty well demonstrated by years of increasing prosperity among laboring men. The present feeling of unrest which it is quite useless to deny has, however, a very different basis, which is worthy of much graver consideration. The question which the laboring man now asks is not whether his handiwork is to be replaced, but whether the fragment of a trade which is left him under modern specialization is sufficient to ensure him a livelihood under average conditions. And the employer asks, not whether he can get well-trained craftsmen, but whether he can meet the sudden fluctuations of supply and demand in face of that complete lack of versatility which the modern methods have enforced.

The situation is a somewhat perilous one, that deserves the sober thought of all men. How far can specialized labor be still further specialized without making the laborer dependent for his daily bread not on his trade, let us say, as a brickmaker, but on the continuity of operation desirable under trade conditions in yard No. 67 of the Cosmic Building Materials Co.?

If industry is to progress some provision must be made for answering this question. It cannot be settled by any method of industrial education or by any mandate of a trades union. It cannot be put aside as part of the old anti-machinery crusade, for it strikes far deeper. When hard times come the man with the hoe is a plutocrat compared with the man who runs the semi-automatic crimper of the Corrugated Leather Washboard Co. The former can still hoe beans, but the latter sits on his doorstep and wonders when the Executive Committee will let the works start up. He has run his machine month in and month out, nine hours a day, with never a change save to quicken his pace when the price of piecework was from time to time cut, and this is the end of his opportunity, and all he knows how to do. The world moves and the day of old-fashioned trades has gone by, perhaps forever, but the new situation faces us with menace, and it remains not to find out a line of retreat, but a practical line of advance. There have been from time to time various experiments in the encouragement of individual effort, in profit sharing and in various sorts of co-operation. They are extremely interesting, even though they only scratch the surface of the subject. They show that men are thinking and working along various lines toward improvement. But it is none too soon, and no activity is too great. The industrial situation cannot adjust itself by the establishment of an apprentice system and a few trade schools, nor by grub-staking baseball teams among the employees. The problem is how to prevent, say, five million workers who have each only a disorganized fragment of a calling from joining the great army of the unemployable when hard times forces them out of their present jobs. The mass of workers imperilled under the abolition of trades is so huge that the problem of dealing with it must be taken very seriously. When the possibilities of the case involve the first principles of self-preservation, as they do in the present instance, it is time for statesmen to take thought.

Steel Rails.

A few weeks ago Mr. Robert Job read a paper on steel rails before the New York Railroad Club, of which an abstract was printed in this journal on Dec. 1. The author had previously gone over the subject in a somewhat different way in a paper read before the American Society for Testing Materials, which, like that presented at New York, led to an important discussion. It is no disparagement of either paper to say that the discussions were, in one sense, of greater importance than the papers. There is a pretty prevalent opinion among engineers not directly connected with track work that there is no general feeling of distrust among maintenance of way men regarding the rails now delivered by the large mills. Just why this opinion is so common it is hard to say, for those maintenance officials who have given their views on the subject to this journal are practically unanimous in considering the present problem of steel rails a very serious one. At the meeting of the New York Railroad Club when Mr. Job's paper was presented, Mr. Ewing, of the Philadelphia & Reading Ry., stated that on one railway 537 rails were broken in one year, of which 82 per cent. had been in use but a year or less; on another line 215 rails broke in a year, of which 45 per cent. were in use not over a year. On still another line 1,324 rails were broken in a year and 21 per cent. of these had been down less than two years; such figures for still other lines were given, but it is unnecessary to repeat them as the few already given are ample to explain the serious nature of the rail problem.

Just what will be the final remedies for the present unsatisfactory character of the average rail deliveries, this journal has not the remotest idea, and it does not believe anybody in or out of the steel industry can do more than guess at them. At the present time the problem is almost hopelessly befogged by a decided clash of interests, for the railway representatives seem to take the position that the mills do not desire to furnish really high-grade rails, while the mill representatives act as though they look upon the railway engineers as a set of hopeless cranks who know nothing about steel manufacture and are asking vain things. Just so long as this condition of mutual lack of respect continues there will not be any progress made, but The Engineering Record is glad to say that the condition is apparently dying out very fast.

It is absolutely out of the question to defend successfully the present average quality of rail for high-speed, heavy and frequent passenger service, and while the mill selling agents may still claim all manner of things in public for their rails it is not unlikely that the technical experts of the larger companies are putting considerable time on the problem of improving the quality of the product. On the other hand, it is gratifying to observe the general acknowledgment by railway engineers of the difficulties which any marked change in rail making will produce in the mills. The latter have been built for tonnage, and any radical alteration in the present process of manufacture will entail high additions to the manufacturing expenses.

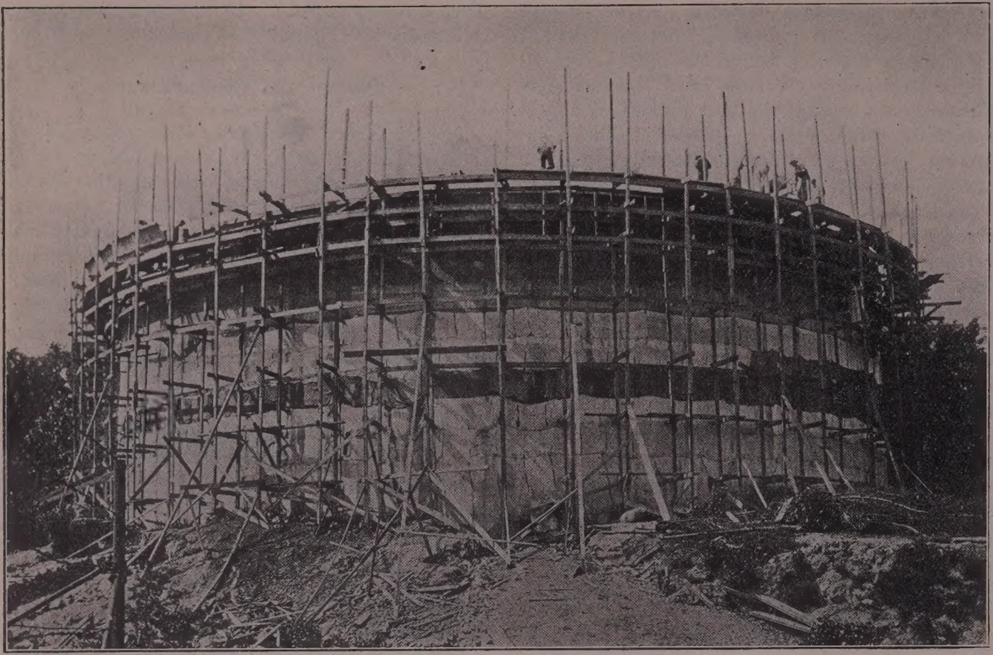
A really satisfactory solution of the problem cannot be reached, however, until a great deal more is known about the manner in which rails are affected by the heavy high-speed service on main trunk lines. It is pretty certain that locomotive axle loads have about reached their maximum and there is every reason, therefore, for believing that money spent now on a good investigation of the wear of rails will furnish data applicable for a long period to come. It is a good thing, of course, to discuss the proper section of rails from various viewpoints and to get together data concerning mill practice, but it is just as necessary to know what effect heavy and frequent fast trains have on the metal in the heads, the webs and the bases of rails bought under average specifications to-day. It is also very desirable to know if rails with a different distribution of the metal or with heads of a different shape will wear better than the shapes suggested by the committee of the American Society of Civil Engineers. The testimony of papers like that by Mr. Job, the information furnished from time to time by maintenance of way engineers, and the comments by metallurgists not connected with rail mills, all lead this journal to the opinion that, at the present time, more is to be learned in the track about the rail problem than anywhere else, but that this information, to be really helpful, must be obtained by means of a truly scientific investigation on a sufficiently broad scale to furnish results of an indisputable nature. It is idle to expect mills rushed with orders to increase greatly their manufacturing charges in order to supply a grade of rails which they do not believe are much better than those regularly delivered, and to go to all this expense without materially increasing their prices. It is equally idle to expect that railway engineers will be satisfied with the grade of rails furnished now. With the mills in their present rushed condition it therefore would seem that progress will be best attained by taking up now the part of the investigation which can be conducted without serious trouble to anyone, namely, the study of the service given by rails put down in 1906 and 1907 on portions of track where the conditions are severe. With these data in hand, there will be little difficulty, compared with what now exists, in getting together for an impartial discussion of the rail problem when the next period of slack business gives those able to discuss the subject an opportunity to do so.

Notes and Comments.

THE FLOATING DRY DOCK, however useful in some respects, is by no means a substitute for a masonry dry dock, although the attention given of late to the former type might lead to such a belief. Chief Constructor Capps is authority for the statement that general repair work cannot be conducted nearly so economically on the floating dry dock, heavy weights can be handled only with great difficulty under such circumstances, and the depth of water in the vicinity of most naval stations is such as to compel the mooring of a floating dry dock of large dimensions at such a distance from the naval station as to make its utilization for anything but painting and minor repair work quite impracticable.

THE IMPORTANCE OF THE TELEPHONE in a large community is well shown by the astonishing figures of the business of the New York telephone system within a radius of 35 miles of the city hall in Manhattan. At the beginning of the present year there were 389,000 telephones in service and under contract in this district, requiring 17,000 employes to operate and manage the business, sixty buildings and nearly 1,100,000 sq. ft. of office space and 182 central offices. During 1906 there were 67,000 telephones installed, more than are used in many of the largest European cities, and the telephone directory is now so comprehensive that it is used very largely as a directory of the old-fashioned type was formerly employed. Although the business is so great and has developed so rapidly of late, it is particularly worth noting that the engineers long ago made provision for this change, by constructing their subways and central stations of ample size for future requirements and by establishing training schools where people are being instructed all the time in the details of various kinds of work. Probably the high character of the service and the fact that the company has always been prepared to handle new connections satisfactorily has been responsible in a considerable degree for the growth of the business. It certainly would have taken on no such dimensions if the service were as poor as that in most European cities.

THE BREAK IN THE HIGH-PRESSURE MAINS used in Philadelphia for special fire protection service, which happened recently, need not cause any apprehension concerning the reliability of high-pressure piping. The conditions leading to the accident were unusual and should be stated in order that the widespread report of the accident may not lead to delay in the construction of such systems in other cities where they are proposed. The pipe that broke was an 8-in. connection made of curved pipe in order to avoid existing obstacles in the street. During the last three years the pipe had been subjected repeatedly to 300 lb. pressure without any indication of failure. Within the last two months the construction of a railway subway along Market St. made it necessary to excavate to a depth of 25 ft. along all of the high-pressure lines in that street. The pipes were slung from the timbering and braced to prevent vibration. While this particular connection was still without complete bracing, the main was put under pressure and the unbalanced side thrust against the curved pipe broke off a flange. The accident did not put the system out of commission, for after manipulating the gates at the end of the broken section the latter was cut out and the fire pressure again resumed. The Philadelphia high-pressure works have long been regarded as a model installation, and it is accordingly gratifying to know that the late accident was not due to any defect in design, material or construction.



General Appearance of Reservoir during Construction.

THE REINFORCED CONCRETE RESERVOIR AT WALTHAM, MASS.

By Bertram Brewer, City Engineer.

The water supply of Waltham comes from an underground source. Water is pumped from a large well near the Charles River. The original works, completed in 1873, included an open well and filter gallery with an open 6,000,000-gal. reservoir on a hill about 1,500 ft. northerly. The objectionable growths, common to underground waters when exposed to light, soon appeared in the water supply. In 1893 the well and gallery were covered, and in 1906 a new covered reservoir was built and put into srvice.

We were aided in our decision as to the kind of structure to build by complete plans and estimates as follows:

First, A concrete covered reservoir of a familiar type, circular, buried in the earth and large enough to contain 2,500,000 gal. of water was estimated to cost about $14,000. This would require taking considerable additional land.

Second, A steel tank, 100 ft. in diameter and about 36 ft. high would contain a little over 2,000,000 gal. and would cost about $30,000. Such a structure would require a considerable outlay for maintenance. It could be built mostly on water-works land.

Third, Careful plans were prepared and a thorough investigation made into the cost of a concrete structure of dimensions similar to the steel stand-pipe, and, like it, to set above the ground. This last design was finally adopted and the concrete stand-pipe or reservoir has now been built at an actual cost of $25,556.

This reservoir rests mostly on ledge. The bottom is 12 in. thick, reinforced with a layer of expanded metal near the surface. The floor is troweled to a granolithic finish. Bent rods were placed in this base spaced every 12 in. They extend 6 ft. into the base of the reservoir and 3 ft. up into the wall. The walls are 18 in. thick at the bottom, the inside vertical and the outside battering 6 in., making the thickness at the top 12 in. Enough steel reinforcement was used in the walls to keep the tensile stress within a 12,000-lb. limit. The rods were arranged in three rows up to 20 ft., and then in two rows in the next 17 ft. The roof consists of a reinforced concrete slab 3 in. thick, supported by steel trusses radiating from a central, concrete-covered, pipe column which serves also as an overflow. These trusses are 3 ft. 8 in. high at the outside ends and an ornamental enclosure wall was built up around and above them; making the total height of the side walls 43 ft. Except in the foundations and lower 6 in. of the floor, which were composed of a 1:3:6 mixture, the concrete was proportioned at the rate of 100 lb. cement to 2 cu. ft. sand and 4 cu. ft. stone and 5 lb. hydrated lime.

The walls were reinforced with 1⅛-in. round rods specified to fulfil the American Steel Manufacturers' standard specifications for railway bridge steel. The jointing of the rods was made, in every case, by a lap of 40 diameters. The cement was required to conform to the standards for Portland cement adopted by the American Society for Testing Materials. The contractor used Lehigh cement. Most of the stone and all of the sand was screened from a gravel bank on city land not far from the site.

As most builders have found to their sorrow, there are certain inherent difficulties in manufacturing concrete which usually render it permeable to water. It was, therefore, with great study and care that the plans and specifications for this reservoir were prepared. The experience in the erection of the three concrete standpipes already built, Milford, Fort Revere and Attleboro, was carefully investigated. In this climate, it is perhaps not so much a question how to stop all percolation as it is to reduce it to so small a quantity as to avoid injury from frost. The peculiar, if not unusual, precautions taken to make the building a success may be grouped under the following heads:—

First—As to the character of sand and gravel which entered into the aggregate.

Second—As to some waterproofing material or compound to be added.

Third—As to method of placing steel and holding it in place.

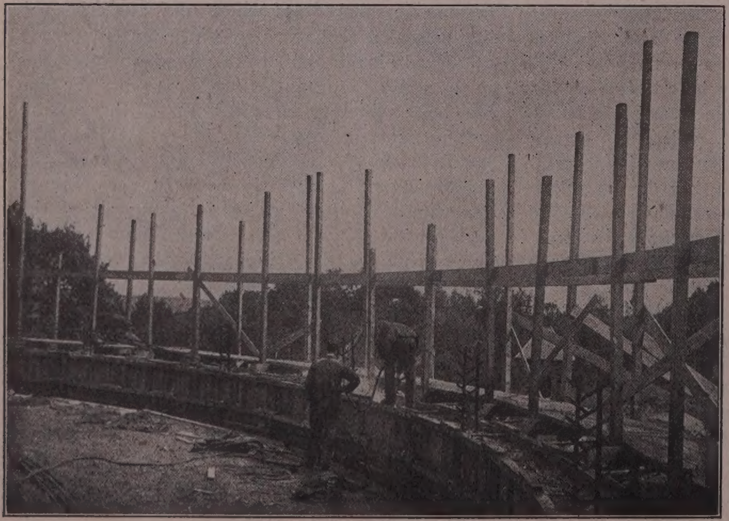
Fourth—Forms.

Fifth—Making the joints and caring for the concrete as it set.

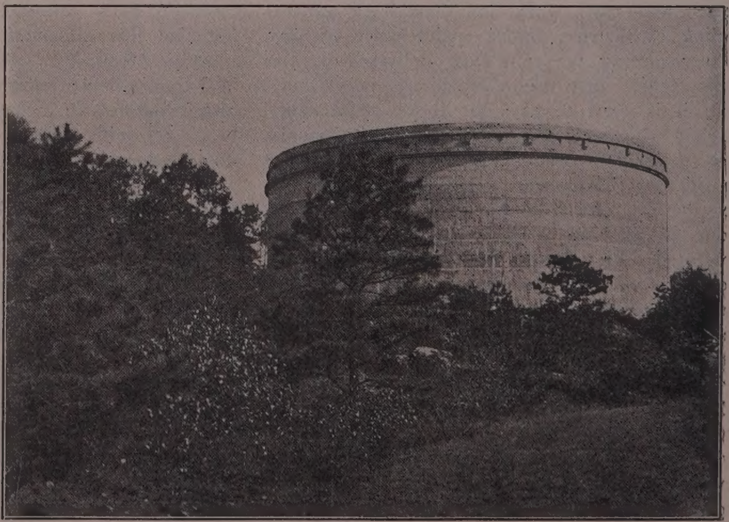
Sixth—Interior finish of walls.

We used, for waterproof work, gravel up to 1½ in. in diameter; using by choice the rounded pebbles because they pack easier and make a denser concrete. Mechanical analyses of the sand and gravel were made and specified proportions of maximum and minimum sizes were adhered to throughout.

Permeability tests were made of two waterproofing materials on the market—Medusa compound and hydrated lime. Both notably increased the impermeability of the concrete, and we concluded to use the lime in the body of the concrete to the extent of 5 per cent. of the weight of the cement, because it gives excellent results and is cheap.

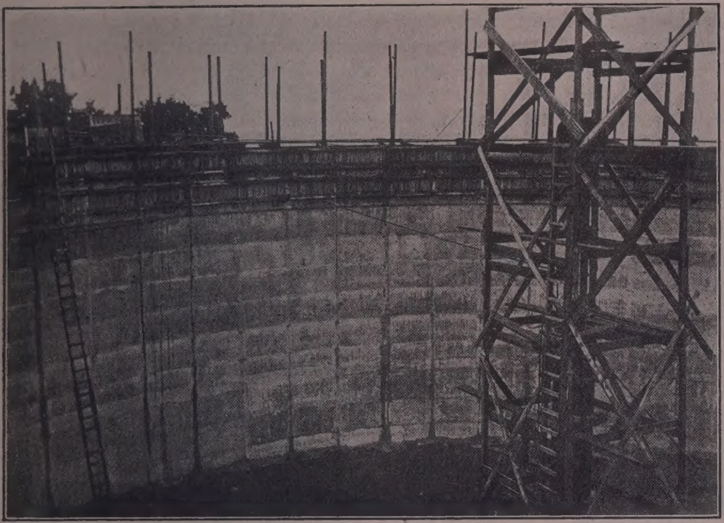


Lower Part of Wall, with Supports for Reinforcement Rings.

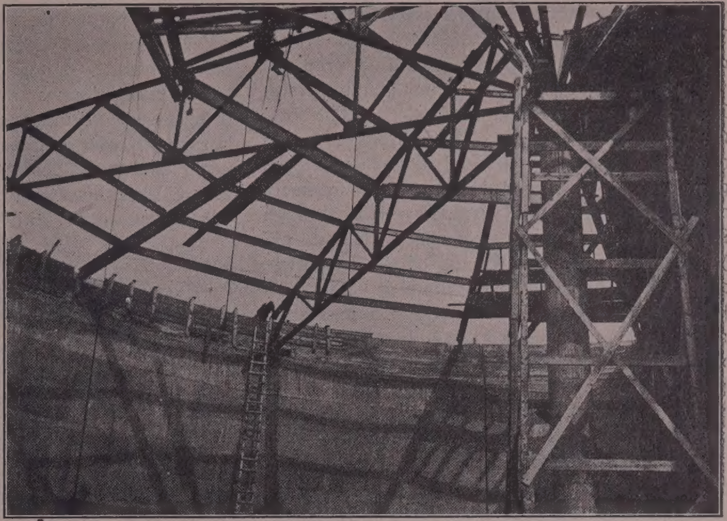


View of Completed Reservoir.

The steel was rolled to the required radius on the ground and placed in the angles of open, lattice-work, perpendicular steel supports as the wall was built up, the ends being tied together with wire where necessary to keep them from sagging.



Interior of Wall during Construction.

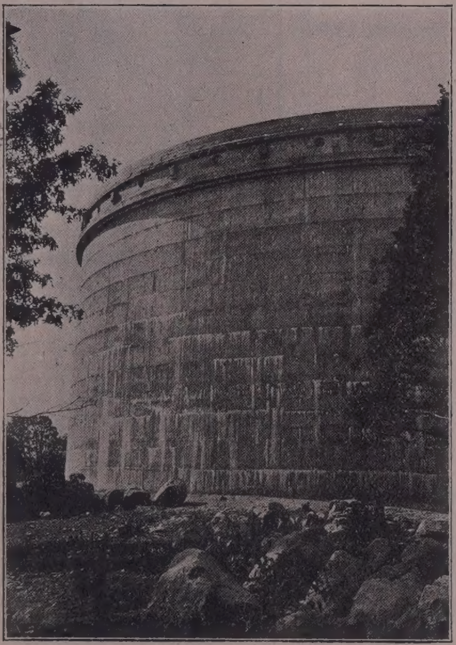


Placing Roof Trusses.

The forms were erected in complete sections 3 ft. high. They were about 5 ft. long, so it took sixty to make the circle. The difference in lengths due to the batter of the outside of the wall was adjusted as the building progressed. The outer and inner portions of each section were tied together with four ½-in. bolts. These bolts were in three sections; the middle section, with the two heads into which it was screwed at either end, was permanently built into the wall, while the two outer sections were unscrewed from the other ends of the heads upon removing the forms. The contractor built two complete sets of these forms, or enough for 6 ft. of wall.

In making the joints the old surface was thoroughly cleaned with steel brushes down to hard material and then washed out with hose. The old work was wet down and a layer of neat cement grout brushed in immediately before adding the concrete. New concrete was kept covered and wet down daily for a month, but no attempt was made to fill the reservoir until it was completed.

The first 10 ft. of the inside wall was plastered with a mixture of sand, cement, lime and Medusa compound, and the remainder received at least two brush coats of a mixture of sand, cement and Medusa compound.

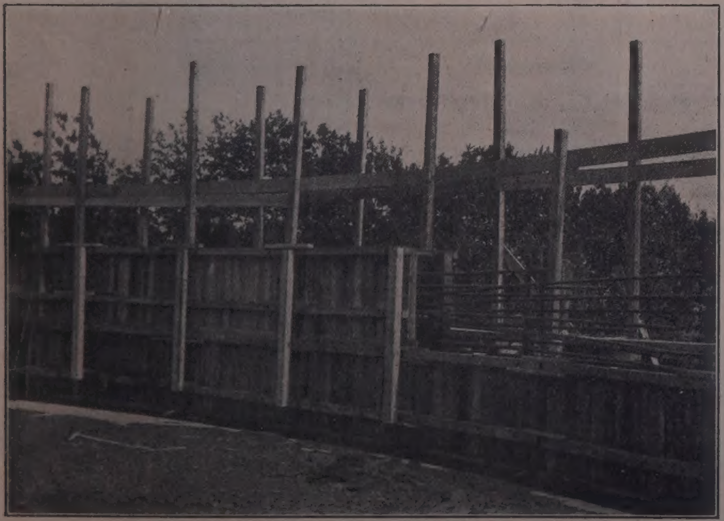


Lime Formations on Surface.

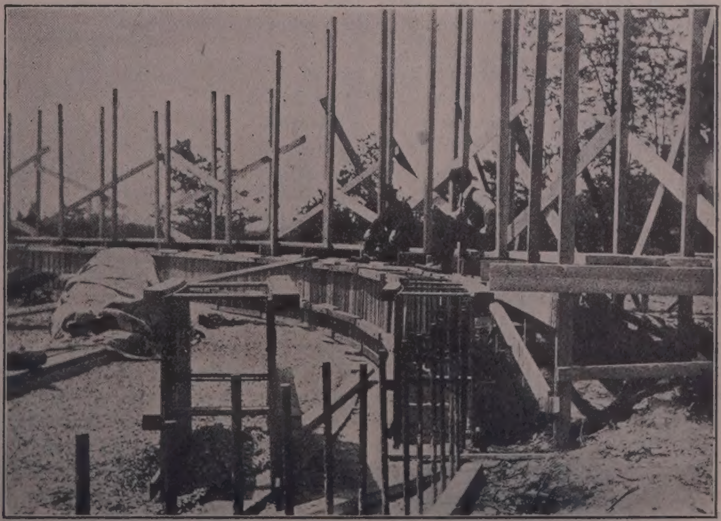
Every structural difficulty was met as we had expected to meet it before we began. There was no movement whatever in the forms and it was not at all difficult to secure the battered walls. The rounded stones were easily packed into place and there are no poor sections of concrete and no leaks. A lack of suitable pumping facilities greatly delayed the progress of the work, and as a result of this delay and an insufficient water supply there has been considerable seepage at the joints. Up to the present time no effort has been made to add to the treatment already described which the inside walls received when first built, with the exception of another brush coat at the joints. The photographs show how the lime has slowly oozed out from the open pores and gradually accumulated in what look like icicles on the exterior but in reality seem to be a sort of stalactite formation. This is particularly well shown in the adjoining view.

In a letter to our city government last February, when preparations for this work were under way, I stated that, if our plans and specifications were carried out, I believed that it was possible to get a concrete reservoir water-tight except for a certain amount of seepage which would be so small as to do no lasting harm to the structure, in the course of its legitimate use. The actual results have fully justified this statement.

Messrs. J. R. Worcester and Sanford E. Thompson acted as consulting engineers. They helped by advice and suggestion to make the structure a success. Simpson Brothers' Corporation of Boston were the contractors. Their engineer, Mr. H. B. Andrews, should be mentioned in speaking of those who contributed toward the preliminary arrangements for a novel building which, in every essential respect, was carried through to completion just as planned at the outset.



Method of Supporting Shutters of Wall Forms.



Reinforcement and Forms at Base of Wall.

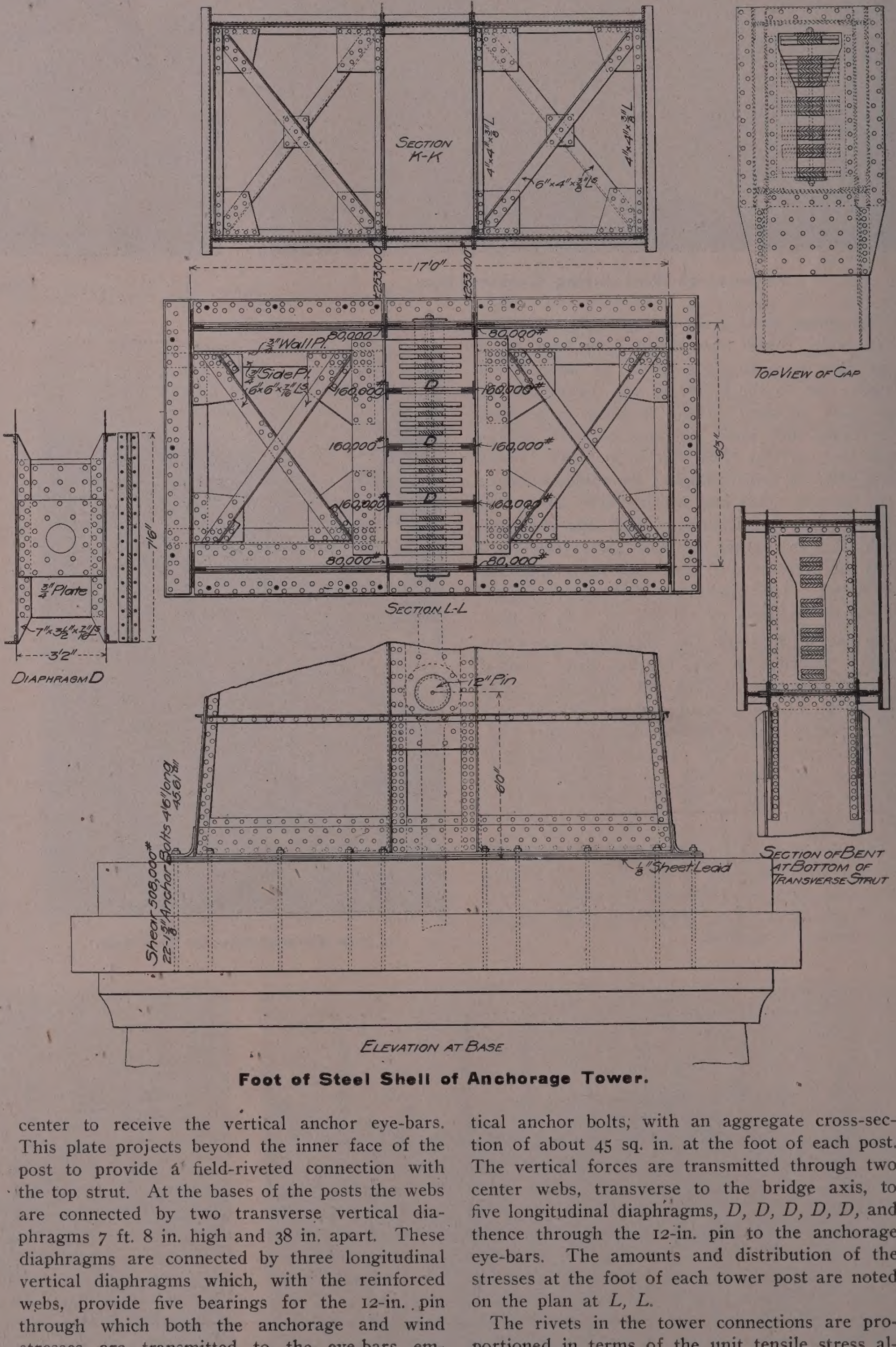
The Anchor Pier Towers of the Quebec Bridge

The general design of the anchor arms of the Quebec bridge was described in this journal on Dec. 1 of last year, and a strain-sheet giving the principal maximum stresses and materials was printed at that time. In the issue of Dec. 29, the adjustable connection of the lateral system in the arms was illustrated, and it is proposed at this time to describe the anchor pier towers at this point the trusses are 97 ft. deep. The total stress of 7,825,000 lb., which is brought to the top of each tower by the end diagonals of each main truss is transmitted from those members to twenty 10x1 11/16-in vertical eye-bars through six short forged links engaging a 10½-in pin 6½ ft. long just above the top of the anchorage tower and entirely independent of it. The vertical eye-bars are proportioned for a maximum and minimum up-lift of 5,213,000 lb., and 1,959,000 lb. respectively, and for a total net area of 337½ sq. in. The eye-bars are proportioned for a maximum unit stress of 15,730 lb., and are about 42 ft. long, connected at the lower end to a corresponding set of bars that, at the lower end, engage a 12-in. pin with bearings in the webs and diaphragms of the vertical post enclosing the tower. The upper pin passes through the webs of the vertical post, but has sufficient clearance there to make it impossible for it to take bearing in the post and thus the eye-bars are prevented from receiving from the lower pin any increment of stress due to wind stress from the lateral systems. This insures their operation only under the live and dead loads of the trusses.

The 1,010,000-lb., direct horizontal transverse stress from the lateral systems is transmitted to the top strut of the tower through the vertical tenon girder described on Dec. 29, and is transferred from the top strut to the two diagonals between the vertical posts. The total vertical stress in each tower post is 666,000 lb., for which a cross-sectional area of 76 sq. in. is provided. The stress in the diagonals is 783,500 lb., with a corresponding sectional area of 54 sq. in. The combined resultants of the vertical and diagonal stresses at the foot of the tower post give a wind up-lift of 1,195,000 lb. The dead load is 157,000 lb., and the longitudinal up-lift from friction is 244,000 lb. The algebraic sum of these stresses is a total of 1,280,000 lb., which is transmitted through the web and diaphragms of the post to the pin and to the lower set of sixteen 10 x 2 1/16-in. vertical eye-bars, which are bedded in the masonry and distribute the combined stresses throughout the pier. It is thus seen that the steel tower is entirely independent of the anchorage and acts only to transmit the stress from the lateral system to the lower set of anchor bars, serving at the same time as a case to enclose the upper sections of the anchor bars.

The tower is about 84½ ft. high and 76 ft. wide at the base and is composed of two battered posts, two diagonal struts and a top and bottom horizontal strut in a vertical plane transverse to the bridge axis. The struts and diagonals have closed rectangular sections and their web plates are field-riveted at the ends between ½-in. gusset plates connecting them to the vertical posts. The diagonals intersect with a miter joint spliced by two field-riveted flange cover plates in the center of the panel. Each vertical post has two web plates 6½ ft. apart at the top and 9 ft. 3 in. apart at the base. They are tapered from a width of 4 ft. at the top to 17 ft. at the base, which is thus extended to give stability on the pier. The webs have a uniform thickness of 7/16 in. and are spliced with horizontal and vertical joints having inside and outside cover plates. Part of the rivets are field-driven, so that its web is divided into pieces of convenient size for shipment. Each web is stiffened by eight longitudinal 7x5-in. angles and by inside and outside horizontal 4x3-in. angles about 3½ ft. apart vertically. The outside vertical angles form flanges to which are shop-riveted tie plates and diagonal angles latticing the two webs together. The webs are also symmetrically connected at intervals by horizontal frames in pairs, one on each side of the center space about 3 ft. wide provided for clearance of the eye-bars.

Stiffening frames are made of 3½x3½-in. transverse and diagonal angles riveted to the horizontal web stiffener angles except at the upper end of the post, where the diagonal angles are replaced by flat lattice bars. Each post has a ½-in. cap plate with a 24x65¾-in. slot in the center to receive the vertical anchor eye-bars. This plate projects beyond the inner face of the post to provide a field-riveted connection with the top strut. At the bases of the posts the webs are connected by two transverse vertical diaphragms 7 ft. 8 in. high and 38 in. apart. These diaphragms are connected by three longitudinal vertical diaphragms which, with the reinforced webs, provide five bearings for the 12-in. pin through which both the anchorage and wind stresses are transmitted to the eye-bars embedded in the pier masonry.



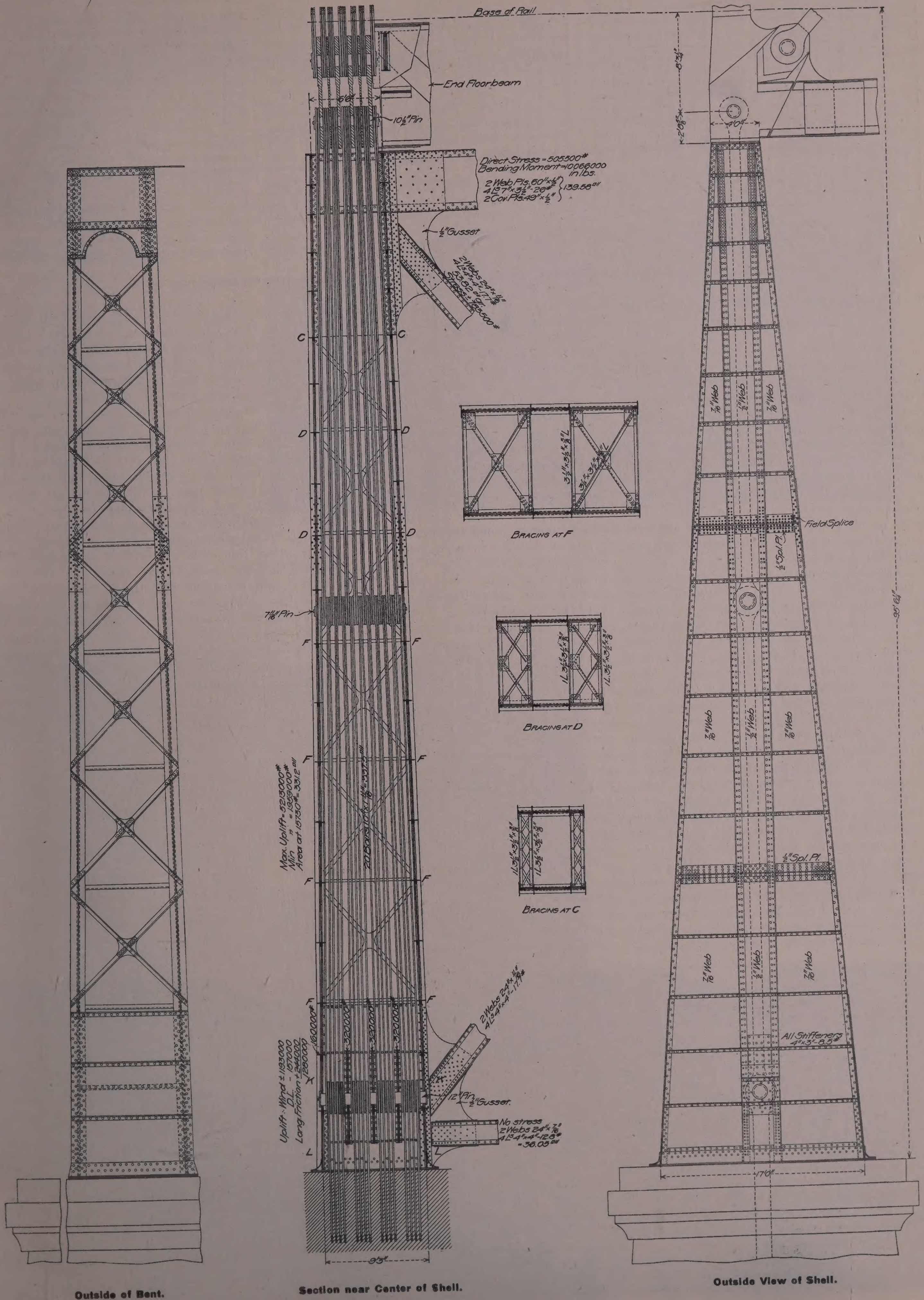
Foot of Steel Shell of Anchorage Tower.

There is a clearance of about 2 ft. between the lower edges of the diaphragms and the base of the post. The base plates are not continuous over the full area of the end of the post, but form a hollow rectangle on the center lines of the web plates and of the tie plates which connect their outer edges. The connection between the post and the base plate is made with wide bent plates having their horizontal and vertical flanges connected by a curve of 3¼ in. radius intended to have sufficient elasticity to allow a vertical movement of about ¼ in. between the post and its base plate, to correspond with the difference of elongations of the anchorage eye-bars under maximum and minimum stresses. The base plates are securely anchored to the masonry and were assembled at first with a ½-in. temporary bed plate which will be replaced by a permanent one of such thickness as is determined by the final elongation of the anchorage bars.

The horizontal forces at the base of the tower are transmitted to the pier masonry through vertical anchor bolts, with an aggregate cross-section of about 45 sq. in. at the foot of each post. The vertical forces are transmitted through two center webs, transverse to the bridge axis, to five longitudinal diaphragms, *D*, *D*, *D*, *D*, *D*, and thence through the 12-in. pin to the anchorage eye-bars. The amounts and distribution of the stresses at the foot of each tower post are noted on the plan at *L*, *L*.

The rivets in the tower connections are proportioned in terms of the unit tensile stress allowed, namely, shop-driven rivets, bearing 1.5 unit tensile stress, *T*; shear, 0.75 *T*; field-driven rivets, bearing 1.1 *T*; shear, 0.55 *T*.

Mr. E. A. Hoare is the chief engineer, and Mr. Theodore Cooper, consulting engineer. The contractor for the steelwork and the erection is the Phoenix Bridge Co.

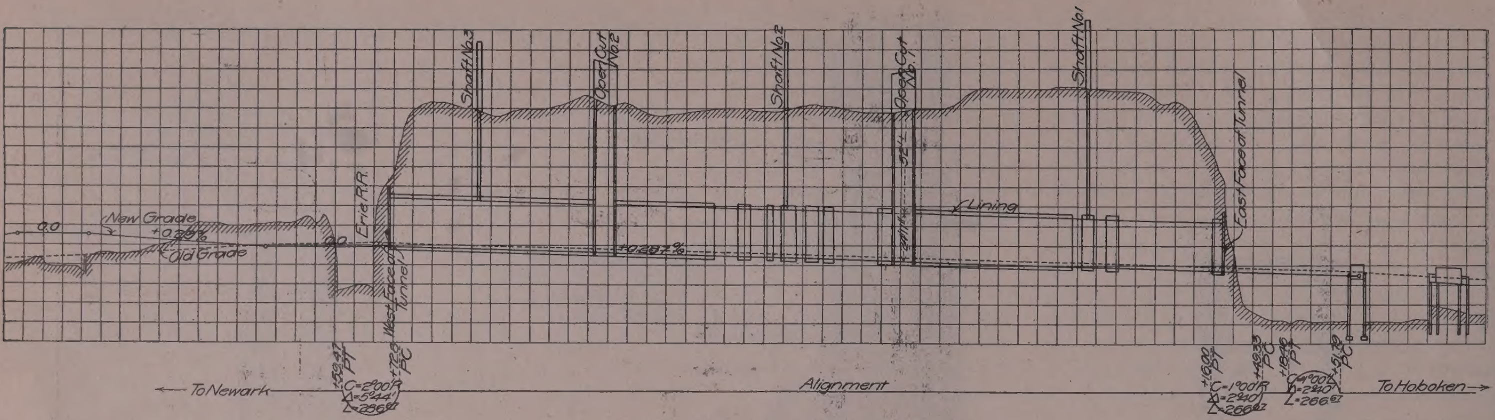


Outside of Bent.

Section near Center of Shell.

Outside View of Shell.

ANCHOR PIER TOWER, QUEBEC BRIDGE.



Profile of New Bergen Hill Tunnel; Vertical Divisions 5 Ft. Apart; Horizontal Divisions, 50 Ft.

The Second Bergen Hill Tunnel of the Lackawanna R. R.

The unusually rapid increase in the volume of both freight and passenger traffic on the Delaware, Lackawanna & Western R. R. in recent years has necessitated the complete reconstruction of the terminal facilities of that railroad on the Hudson River, at Hoboken, N. J. This reconstruction includes a new passenger terminal station and yards, which are approaching completion, the rearrangement of the freight terminal yards and the erection of an entire new series of piers and piersheds. When the general plans covering these improvements are executed, the Lackawanna will have one of the best-equipped terminals along the water front in the vicinity of New York City for handling both freight and passenger traffic, the total dock frontage according to the latest plan being nearly 4,000 ft. The inlet and outlet to all of these terminal yards and facilities has always been through a double-track tunnel, 4,280 ft. long, that passes through Bergen Hill about a mile from the water front and is operated as a single absolute block. The Morris & Essex division and the Boonton Branch of the Lackawanna join at the western end of this tunnel. The former was the original main line, but now handles almost exclusively a suburban passenger traffic between the populous district of northeastern New Jersey and New York City. The Boonton Branch is the most direct route to Buffalo and is now used as the main line, all freight for Hoboken, Jersey City and New York, all export freights and all but two through passenger trains being operated over it. The entire business on the eastern end of the road, including over 215 scheduled passenger and 13 scheduled freight train movements every 24 hours, as well as extra trains and drill engines, thus has to be handled through the Bergen Hill tunnel.

The new tunnel is being constructed as a relief for the old one and will be built so changes can be made in the old tunnel that it is believed will permit both the old and new tunnels to be operated in three blocks, thus enabling a greater volume of traffic to be handled through both of them. The new tunnel will have two tracks and is to be parallel with the existing one, the center lines of the two being 51.5 ft. apart. Its portals are flush with those of the present tunnel so that it has a total length of 4,280 ft.; it is also on the same grade as the present tunnel, which is descending eastward at a rate of about 18 ft. to the mile. The old tunnel has a clear width of 27 ft. and a clear height of 20 ft. 5 in. at the crown of its elliptical arch roof. It was driven through traprock and is lined for three-fourths of its length with four rings of hard brick laid in cement mortar, with a coating of asphalt mastic on the outer surface of the brick lining. The new tunnel will have a clear width of 30 ft. and a clear height of 23 ft. 5 in. above the base of the rail at the crown of the roof arch, which is semi-circular. The two tunnels will thus be separated by a wall of rock varying from 19 ft. thick at points where both tunnels are lined to 23 ft., where both tunnels are unlined. The rock that has been encountered thus far in the headings of the new tunnel is of the same character as that in the old tunnel. The new tunnel will be lined for at least three-quarters of its length with a 2-ft. layer of concrete.

The sub-grade of the new tunnel will be cut so as to drain to a ditch, 1 ft. deep below sub-grade and 2 ft. wide, along each side. A ditch of the same dimensions will be placed longitudinally at the center line, and in each of the three ditches a line of 8-in. vitrified drain tile will be laid. Where the tunnel is lined weep holes will be built 50 ft. apart or less at the bottom and extended through the side walls. Vertical drains, 8 in. square, will extend in the back of the concrete lining next to the rock from these weep holes to the crown of the arch.

The new tunnel will have three air shafts, 10 x 30 ft. in plan in the clear, extending to the surface of the hill through which the tunnel is driven. Two open cuts 80 ft. wide by 100 ft. in length and extending over both tunnels, are also being made. The spacing of these air shafts and open cuts may be seen from the accompanying profile of the tunnel. The air shafts will be lined with 2 ft. of concrete and their side walls will be flush at the bottom with the side walls of the tunnel. A chimney, or shaft extension, 20 x 40 ft. in plan and 35 ft. high above the ground level, will be erected at the top of each shaft. These chimneys will have concrete walls 1.5 ft. thick. To prevent any large accumulation of ice from falling into the shaft, two horizontal layers of 80-lb. rails will be placed in the latter near the top. The rails in each layer will be 20 in. apart on centers, those in the two layers being placed so as to form a diagonal network. Vertical drains will be left in the rear face of the concrete lining of the ends and sides of the air shafts and will discharge into the side ditches in the tunnel.

The two open cuts are about one-third the length of the tunnel from each end. They were each made by the contractor in lieu of 100 ft. of regular tunnel work and one shaft, with the idea that headings would be carried forward from them in both directions and the excavated material from the new tunnel removed through the present tunnel. The tunnel headings will be driven in both directions from both open cuts and from both portals simultaneously. One of the open cuts has a total depth of 77 ft. to

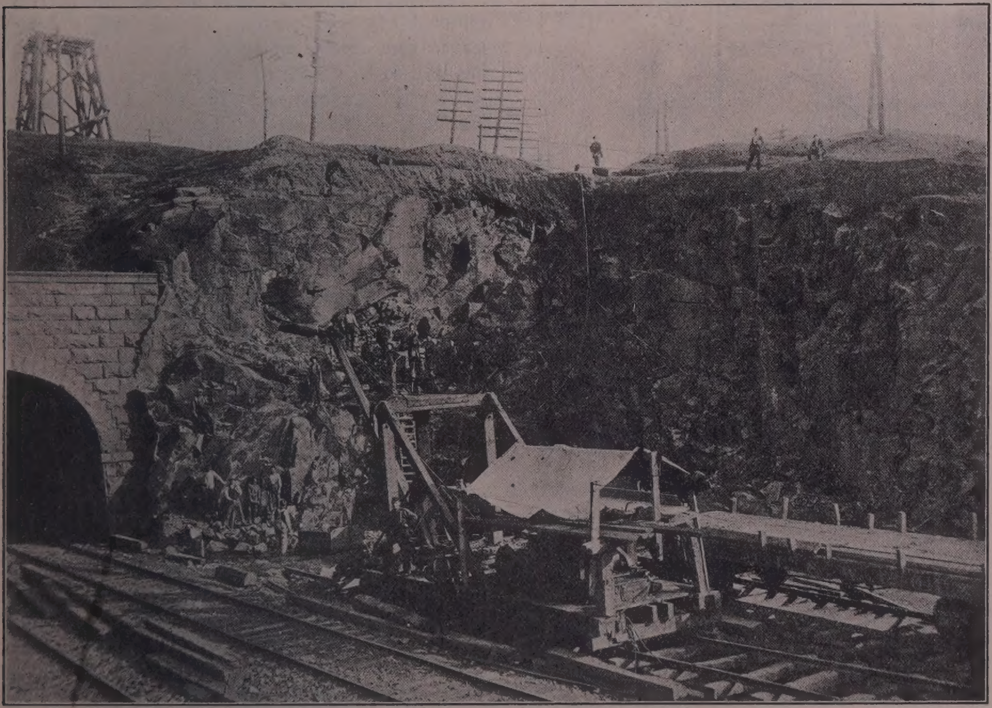
Two Views of Work in Progress on Open Cut of Bergen Hill Improvement, Lackawanna R. R.

the bottom of the tunnels, and the other a depth of 76 ft. Both cuts are to have a lining of concrete, 2 ft. thick, in front of the natural rock, and this concrete construction will be extended 20 ft. above the ground surface for protection.

The contract for the construction of the new tunnel, including the open cuts and shafts and other work was awarded to the Wm. Grace Co., of Chicago and New York, on March 27, 1906. The contractor installed an outfit of electrically operated rock drills which were provided with power from a central generating plant set up near the open cut next to the west portal. These drills did not prove efficient on this work and air drills are being substituted for them. Blasting is confined to four periods of 15 minutes each during the 24 hours, train schedules having been arranged accordingly.

The open cuts are being made through rock, which is blasted out in the usual manner. The excavated material is raised to the surface in skips handled by derricks set up at the surface, the material being dumped from the skips into wagons in which it is hauled to storage piles or to a dump. As much of the good rock as is required for concrete is crushed by the contractor and is paid for as crushed stone by the railroad.

Before removing the arch of the lining of the old tunnel at the open cuts a falsework of timber and bent T rails is built up in the tunnel so as to provide proper clearance and on the bent rails of this falsework 3-in. lagging is laid directly against the brickwork. The open cuts are to be excavated to sub-grade and the portion of the lining of the old tunnel in them is being removed. In the part of the brick lining of the old tunnel that has already been taken out in this manner the brick work was found to be in very good condition when it was uncovered; the coat of asphalt on its outer surface is still plastic although the tunnel was completed 30 years ago.



Approach Cut at West Portal, Bergen Hill Tunnel.

Approach cuts in rock had to be made at both ends of the tunnel before the headings could be started at the portals. The cut at the east end was 100 ft. long and contains 5,700 cu. yd. of material; the one at the west end is 120 ft. long and contains 8,450 cu. yd. of material. Both cuts are practically all in rock which was also removed between the lines of the old and new tunnels up to the portals. The excavation in these cuts had to be made in a manner that would not interfere with traffic on the adjacent tracks. The material from the east approach cut was used in widening the embankment on which the approach to the tunnel is made; that from the west approach cut was hauled away and utilized for filling by the railroad company.

The headings at both portals were started as soon as the approach cuts were finished, the one from the east portal having been driven 120 ft. and the one from the west portal 89 ft. on Dec. 15. The headings from the open cut have not yet been started. Night and day shifts will be employed continuously until the work is completed. The heading, bench excavation, side wall lining and lining of the arch are to proceed at the same time when work has progressed far enough to allow such prosecution.

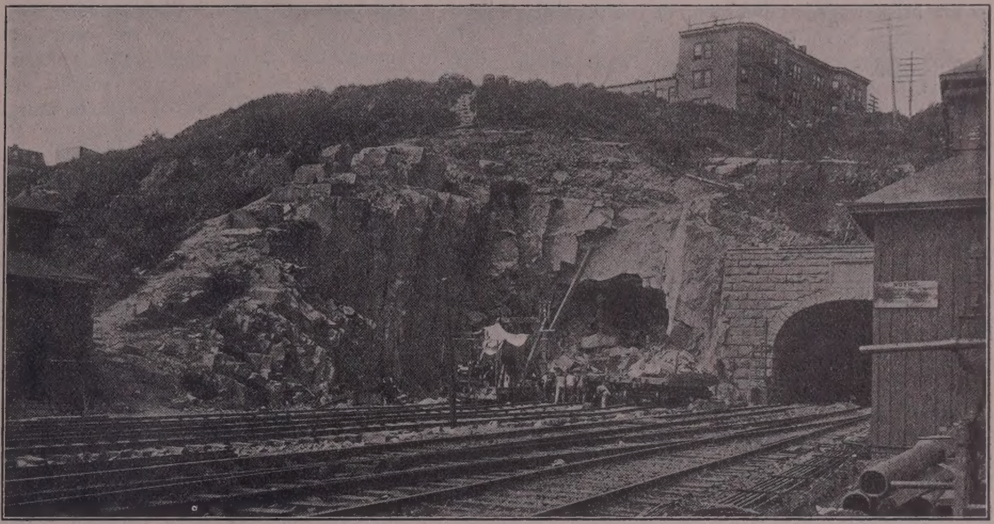
The railroad company supplies all concrete materials except the crushed stone which is provided by the contractor, but is paid for as crushed stone, as has been noted. The proportions of cement, sand and crushed stone for concrete may be varied by the engineer in charge to suit the conditions.

The completion of the new tunnel will enable all traffic to and away from the terminal to be handled expeditiously until traffic has reached a volume greatly in excess of that existing at present. The new tunnel was planned and is being built under the direction of Mr. L. Bush, chief engineer of the Delaware, Lackawanna & Western R. R., with Mr. F. L. Wheaton in immediate charge of the work.

A New Hydro-Electric Plant in Wales.

A hydro-electric power development has been made in North Wales by means of which an effective head of 1,140 ft. is utilized, capable of producing 6,000 h.-p. Two small lakes situated on Mt. Snowden, some 1,500 ft. above sea level, were utilized as reservoirs from which duplicate pipe lines, about 6,500 ft. long, laid to a power house in the valley below, by which an effective pressure of about 500 lb. is secured. The pipe lines are constructed for the greater part on a sharp descent, which increases just above the power house to an angle of 45 deg. The pipes taper from 30 in. in diameter at the reservoir to 27 in. at the lower end, the upper portion consisting of riveted steel pipe and the lower portion of welded flanged pipe. The pipes are in 18-ft. lengths, laid on wooden sleepers and rigidly anchored; monuments have been erected along the pipe line providing fixed points which will enable any movement of the pipe to be detected. The generating equipment consists of four 1,500 h.-p. twin impulse Pelton wheels direct-connected to 10,000-volt, 50-cycle alternators, the wheels being regulated by hydraulic governors acting on needle nozzles. The reserve storage in the lakes will enable the station to be operated for 180 days at this capacity without any rain whatever, and either one of the pipe lines will carry the present station service. Power is distributed to a number of the large slate quarries for which Wales is famous and to several nearby villages.

PRIVATE LIBRARY OF FRANK A. RANDALL Case No.



Approach Cut and Heading at East Portal.

BURNING COKE IN LOCOMOTIVES on the Baltimore & Ohio R. R. has been practiced successfully for some time in the Pittsburg district. Instructions recently issued by the Motive Power Department give special attention to the starting of the coke fire, ordering wood and semi-bituminous soft coal to be first applied to the grates in order to assist in igniting the coke and prevent it from clinkering over the grate surface. After this coal is thoroughly ignited, the coke may then be introduced until the fire box is filled, the steam blower being used until the coke is well burned through and forms a solid body of fire. It is ordered that the fire be then left in this condition until the locomotive has commenced work and run 15 to 20 minutes, after which, at the first opportunity when the engine is not being worked under steam, the fire box is to be refilled with coke.

A Steel Clock Tower.

The steel clock tower for the Long Island Storage Warehouse, at Nostrand and Gates Aves., Brooklyn, is about 160 ft. high from the street to the top of the lantern and rises 66 ft. above the top of the roof beams on which it is seated. It is about 14 ft. square at the base and the framework, except the I-beam second floor, is built almost entirely of light single angles. It is supported on transverse and longitudinal beams and girders connected to the interior columns and to the brick walls, as indicated in the plan diagram, and is eccentric with the 23 x 26-ft. panel formed by the exterior girders and walls which support it.

The lower part of the framework consists of a pair of vertical stresses 4 ft. wide and 39 ft. high in each of the exterior faces of the tower. Two trusses are thus adjacent at each corner, and the pairs of trusses are braced together across the faces of the tower by the upper and intermediate floor beams and by the clock frames at the other end. The feet of the trusses are stiffened and the base of the tower is extended by curved knee-braces projecting 5½ ft. horizontally in the diagonals of the corners.

At the top of the trusses there is a platform 14 ft. square, made with a continuous outside horizontal flange angle supporting two transverse and two longitudinal floor angles and serving as the base for a dome 7 ft. high, made with radial curved T-bar ribs converging to an upper 6 x 6 x ½-in. angle ring 4 ft. 2 in. in diameter. Above the dome, the construction is continued by an octagonal shaft 12 ft. high and made of eight 3 x 3-in. vertical angles riveted at the upper end to a horizontal ring made of a 4 x 3-in. angle, which also serves as the base for the hemispherical lantern roof, having eight radial ribs made of 2 x 2 x ¼-in. T-bars riveted to a 3 x 2-in. circular top angle 18 in. in diameter. The horizontal upper flanges of this angle are connected by tie plates intersecting in the center, where they are bored for a 1-in. vertical rod 6½ ft. long, which is secured at the base of the dome by double check nuts engaging a horizontal bearing plate there. At the foot of the octagonal shaft, there is an octagonal projection 7 ft. wide and about 3 ft. above the base of the shaft. This has twelve cantilever angle brackets connected at the outer end to a horizontal facia angle and at the inner end to a circular drum 2½ ft. in diameter, made of a 9 x ¼-in. vertical cylindrical web plate and a 2 x 2-in. upper flange angle. This drum serves as a curb fitted with a trap door to permit access to the top of the tower.

Wind bracing provided by the vertical trusses and by the diagonals and knee-braces has sufficed to make a rigid structure which has been exposed to severe winds without injury or serious deflection. The architectural requirements involved a large number of small angles and a great variety of different members. Skill and ingenuity were exercised in designing them so as to have simple and efficient connections easily made in the shop and quickly and accurately fitted in the field. This was accomplished principally by making direct field-riveted connections between the flanges of angles in the different members and by the use of simple angle clips and splice plates at abutting joints. The details had effective treatment for light architectural work of this character and those shown for the dome and lantern shaft are typical of the whole tower.

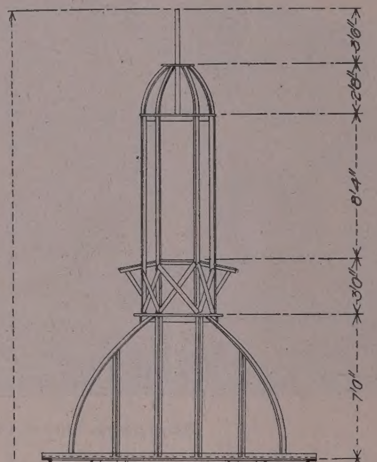
Messrs. Helme & Huberty were the architects, and Post & McCord were the contractors for the fabrication and erection of the steel work.

The Cost of the Ventilating Equipment of the Boston subway, by which satisfactory atmospheric conditions have been secured, was less than 1 per cent. of the cost of the subway.

Some Problems Connected with Deep Mining in the Lake Superior Copper District.

Address before the Engineering Section of the American Association for the Advancement of Science, by President F. W. McNair.

The copper mines of the Lake Superior district are essentially low grade. Their profitable operation is made possible by the great extent of the lodes, their comparative uniformity of character and the investment of great sums of money to maintain operations on a vast scale over a long period of years. With but one important exception, the lodes are the vesicular tops of ancient lava flows, which subsequent to solidification, have had the cavities wholly or partly filled by the deposition of various minerals, among which is native copper. They dip at angles varying from 38 to 70 deg.



Side Elevation of Tower Above Roof.

The modern shafts through which the rock is hoisted are either inclined, following the plane of the lode, or are vertical. The inclined shafts are of dimensions such as to provide for two railroads of approximately standard gauge on which run the "skips" which are operated in balance. In addition there is room for the ladder way and air pipes, usually placed at one side. The vertical shafts have compartments providing usually for "cages" and pipe and ladder way. Several of the inclined shafts are over 5,000 ft. long. One has a length of 8,100 ft. Of the vertical shafts the three deepest are, respectively, about 5,200, 5,000 and 4,900 ft. deep.

Pillar Loads.—Long before such depths were actually reached there arose the question as to a possible limit set by the ultimate crushing strength of the rock which is penetrated. Manifestly, mining can not go to a depth such that the weight on walls of drifts and stopes will exceed the ultimate strength of the material of which they are composed. There is a widespread impression that the lake mines are approaching such a limit. There are current statements to the effect that pieces of rock occasionally snap off the rock faces because of the great strain, and are violently projected as if propelled by an explosive.

In this connection a few figures will be of interest. The average density of the rock of the copper-bearing series is not far from 2.87, that is, a cubic foot weighs about 179.3 lb. Therefore, a horizontal square foot of area at 5,000 ft. from the surface has above it a column of rock weighing 448 tons. The ultimate crushing strength of the average rock is not well known, but since it is mostly trap this may be safely assumed as at least 1,200 tons per square foot. If, therefore, the square foot above defined carries the entire column above it, it is loaded to much less than half the crushing strength and only at nearly three times the assumed depth will the load reach its crushing limit. At a dip of 38 deg., the pressure normal to the plane of the lode at 5,000 ft. from surface is only 354 tons per square foot. It is in this direction that the crushing forces are mostly called into play. As the dip increases this normal pressure, of course, diminishes. At 52 deg. it is 278 tons, and at 70 deg. it is 152 tons per square foot.

However, the matter does not end here. The removal of large portions of the copper zone leaves considerable areas of the roof or hanging wall to be supported by the pillars which are left for the purpose, or by the walls of the opening, or by both. The weight on pillars and walls is thus increased and may easily approach the crushing limit. Take, for example, a long pillar 50 ft. wide having on either side an open space of 150 ft. Suppose it in a lode dipping 38 deg. Allowing for neither rigidity nor arching, and supposing the weight on the pillar evenly distributed, at 5,000 ft. deep it would be subjected to a pressure of 1,239 tons per square foot, a pressure under which it would fail.

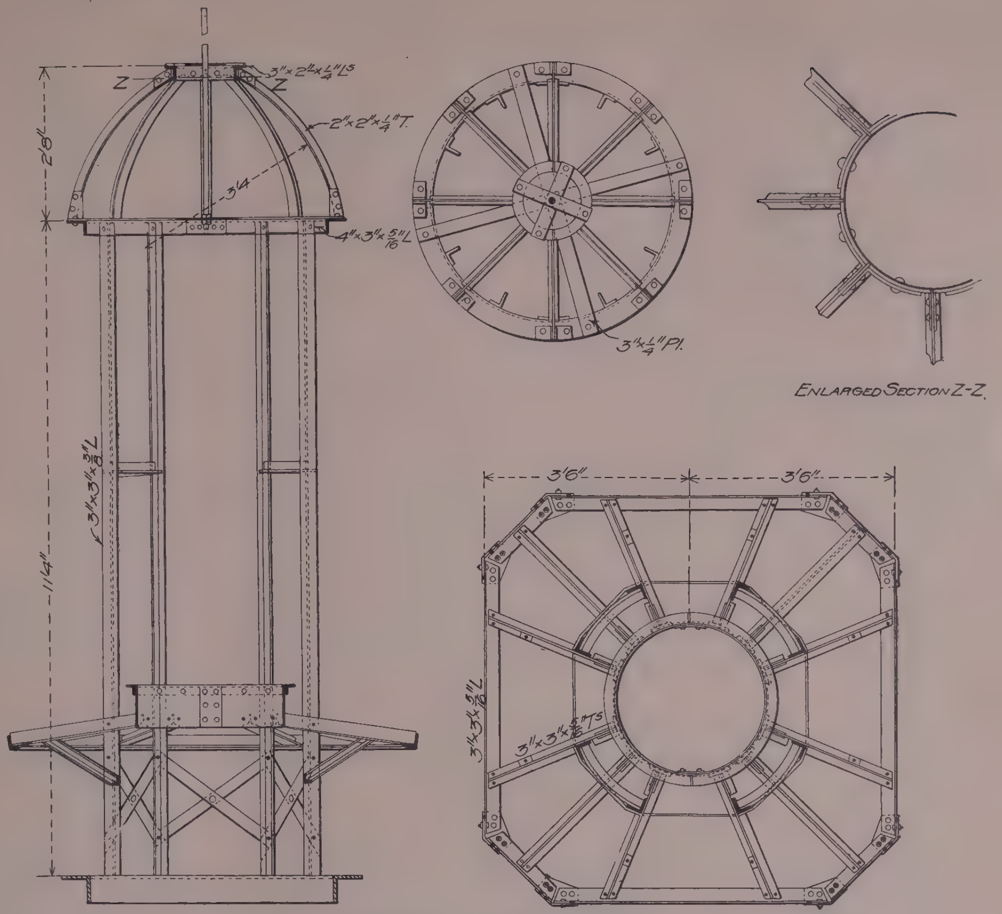
As a matter of fact, in such a case the rigidity of the rock mass distributes a large part of the load out over the rock beyond the walls of the opening. That this rigidity may be considerable is illustrated in several cases where areas of hanging as wide as 200 ft. or more have no support between walls, and yet have stood up for several years. They are not, however, at maximum depth. In such an area a pillar when first cut out may have to carry but little more than its previous load. As the hanging wall slowly bends the pillar must take up more and more of the extra weight. This is not applied uniformly. As the rock between pillars and walls bends downward the tendency is to concentrate the load at the edge or face of the pillar, or wall, much as a beam does when supported in like manner. The outer parts of the pillar may thus become overloaded and here it will fail.

It does so by the splitting off of pieces of rock much as may sometimes be observed with a specimen in the testing machine, though on a much greater scale. These pieces break from the base as well as the top, and, as a rule, like any hard rock under a crushing load, the pillar fails suddenly. Small pieces of rock may fly to a considerable distance, and such occurrences have undoubtedly given rise to the above mentioned exaggerated impression of the compressive stress to which the rock is subjected in the lowest levels.

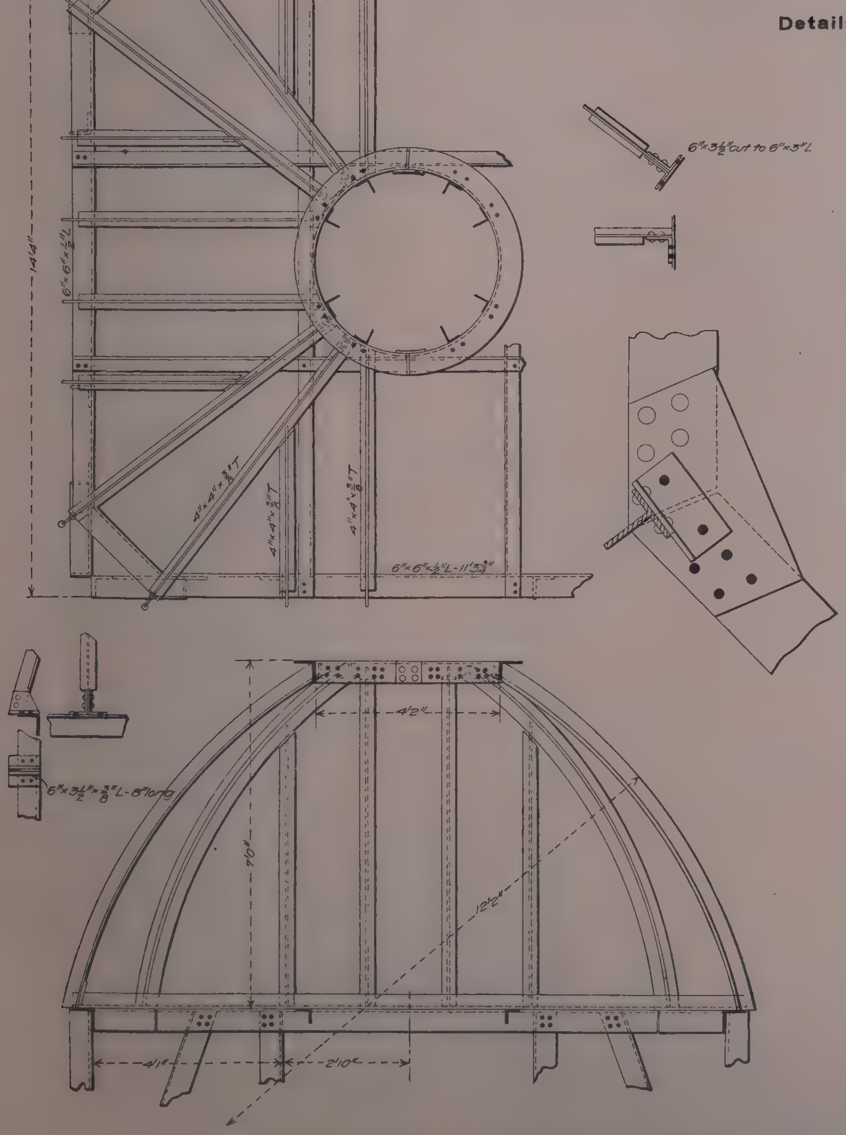
The hanging rock mass moves, of course, when the pillar crushes, and the vibration due to the sudden though slight displacement is often conveyed to the surface. The result is a miniature but perfcetly genuine earthquake which may be felt over a distance several times that of the pillar from the surface. With the crushing of the pillar and the movement of the hanging a readjustment of the weight takes place, and the process begins over again. Instead of the process being repeated exactly it is possible for the hanging to break in such a manner that the arching effect may protect this pillar, and place the load on others. Eventually, at great depths the hanging and foot must come together, and in one mine the final steps in the process came so rapidly as to wreck it completely.

The pressure normal to the plane of the lode is not the only action which may appear. The pillars are not, as a rule, separate from either foot or hanging. They are parts of the same rock mass, and it is not possible for the hanging to slide over the pillar. In consequence the readjustments which take place when a pillar fails as above described sometimes put an enormous longitudinal thrust on the foot, and in places its surface portion has buckled up under such stress. Also, at points where shaft pillars have been weak, shafts have been pinched and twisted under the same conditions so as to interfere with their operation.

Experience seems to have shown that at the great depths recently reached it is useless to expect to hold up the hanging rock mass for a long time by any scheme of pillars unless far too much of the lode is left in place, and that the only feasible method is to cut away the entire lode and permit the hanging to cave as rapidly as it will to the point where the broken rock fills again the whole space, and redistributes the weight over the footwall. Following this plan, cutting out the lode, or "stoping," begins at the point furthest from the shaft, and progresses toward it. With a wide shaft pillar, or with the shaft in the footwall, and with some such general method which avoids concentration of pressure where it can do harm, there seems no reason to anticipate serious difficulties due to crushing for a further depth at least as great as that already attained.



Details of Lantern on Dome



Details of Dome of Steel Clock Tower in Brooklyn.

Surveying.—The difficulties of surveying the mine are not markedly increased by depth, except in the case of vertical shafts. When these are deep, and it becomes necessary to carry down an azimuth from the surface by means of two plumb lines hung in the shaft, there is presented a problem of considerable difficulty. It is almost impossible to free the lines entirely from disturbing influences which displace them from their normal positions. If either lines or plumb bobs are of magnetic material the presence of iron pipes in the shaft may result in seriously disturbing them. Falling water may be in such quantity and so directed as also to affect the position of the lines.

However, the air currents, which can not be wholly eliminated, whatever the precautions taken, are the most serious cause of disturbance. The temperature at the bottom of the shaft is higher than that at the top, and in consequence convection currents are formed. The heat supplied from the surrounding rock keeps them up. Indeed, with moderately steady temperature at the surface, and with the shaft idle, a remarkably stable condition of these air currents may come about. Observations have been published by the writer, showing that their effect on a plumb line may remain sensibly constant for hours at a time while deflecting the line from its vertical position. The stability of the currents is made possible by the large cross-section of the vertical shafts, 10 x 22 ft. to 10 x 30 ft. outside of timbers, thus giving a large air body, and the constancy of the rock temperatures, and the supply of heat through the shaft walls. When we take account of the fact that a force equivalent to a horizontal pressure of 10 grains on a 60-lb. plumb-bob suspended by a line 4,000 ft. long will displace the bob one-tenth of a foot from its normal position, it is easy to see how apparently slight causes may produce appreciable error in azimuth.

General attention was first attracted to this problem by the very noticeable divergence of two long plumb lines hung in shaft No. 5 of the Tamarack mine. Of course, divergence alone would not affect azimuth, but the question confronting the surveyor is whether the divergence may not be due to some cause which may also displace one or both of the lines in a direction perpendicular to their plane. In the case mentioned it required a great deal of investigation and experiment to fasten the responsibility on the currents of air.

It is remarkable how many persons are ready to accept as an explanation of such divergence the statement that there is an excess of gravitation on each bob horizontally toward the end wall nearest to which it hangs. All are familiar with the picture in the text-books of the plumb line hanging near the face of a precipice being deflected from the vertical by the attraction of the mountain mass. The idea so strikingly conveyed by this picture while qualitatively correct seems in most minds to be quantitatively wrong. There is an excess of attraction on the bobs as stated, but its amount is far too insignificant to account for any observed divergence. At Tamarack No. 5 it could account for no more than one one-thousand of a foot. The convergence of vertical lines in that instance is over three times this amount. The fact remains that the surveyor who must thus transfer an azimuth from the surface down a very deep shaft has a problem the proper handling of which must involve a careful study of the local conditions, particularly in regard to air circulation.

Hoisting.—Increased depth tends to lessen the output of a given shaft, and in the effort to prevent this, and also to reduce hoisting charges, loads have grown larger, likewise the speed at which they are hoisted. Loads of nearly seven tons are being raised on some of the inclines at speeds up to 40 miles per hour.

A considerable item in the hoisting charges is the cost of maintenance of the skip road, the expense per ton for this purpose increasing with the length of the shaft. The usual skip road is carried on heavy timbers which are placed transversely along the foot, and support large stringers to which the rails are spiked. The expense of maintenance of this road for great depths is such that some of the mines are substituting for it a road consisting of a rail attached to a concrete stringer which is borne directly on the rock of the footwall.

The stringer proper is about 13½ in. wide by 14 in. high. Beneath it and supporting it is a mass of concrete 16 in. to 18 in. wide extending to the rock. The depth of this supporting mass varies considerably, depending on the irregularities of the rock face to which it is attached. It ranges all the way from 4 in. to 2½ ft., and there is no reason why these limits might not occasionally be exceeded. The stringer and supporting mass are structurally one piece, being molded together. The stringer portion is reinforced by means of a 1⅛-in. steel cable passing longitudinally through its interior. The rail is attached by bolts which are spaced 3 ft. apart, and hold it by means of clips which grasp the rail flange. The bolts pass through the stringer into a rectangular opening about 3 x 4 in. in section, which passes quite through the concrete, and affords access to the lower end of the bolt.

In building the road a form of plank is constructed having the cross-section of the stringer, and a length of 15 ft. To its lower side are nailed the cores for the bolt openings just mentioned. The top is left open. From one to three of these forms are supported in place underground by suitable means, and to the sides are nailed boards extending downward to the rock. These make the form for the supporting part underneath the stringer proper. When all is firmly secured the rock face is thoroughly washed, and the concrete is filled in, beginning at the lower end. The mixture used is one part Portland cement, three of sand and five of crushed rock, and it is tightly rammed in place. As the filling proceeds the top of the form, or the cover, is completed by nailing on short pieces of plank. In the roads which have been built at a slope of 70 deg. the structure is anchored to the foot wall by heavy bolts spaced 8 ft. apart. When the concrete has hardened sufficiently the form is removed and the rail is bolted in place. The road is then complete.

The first of these roads has been operating some three years, and has proved so satisfactory that the others have followed. Expectation regarding cost of maintenance has ben fully realized, and, in addition, it has been found that the original cost of the road is less than that of wooden construction. Its disadvantages seem to be confined to the fact that, due to the unyielding nature of the support, the effect of a blow must be absorbed between wheels and rail, resulting in a perceptibly greater deterioration of both. However, this is far more than compensated by the decreased cost in other directions and the fireproof character of the road.

Power.—In the effort to counteract the increased costs due to great depth the economical generation, distribution and use of power have naturally received large attention. The long period of operation necessary makes it worth while to expend large amounts of money in installing machinery of large capacity and high economy. The extreme in the direction of high-duty engines is represented at present in the Nordberg quadruple expansion, two-stage air compressor operating at the Champion mine. The engine is equipped with Nordberg's regenerative feed water heating system. It holds the world's record for minimum consumption of heat per foot-pound of work delivered, having shown a duty of 195,000,000 ft.-lb., being about 9 per cent. in advance of its nearest competitor.

But one mine is so situated to be able to make use of water power. The Victoria, located near the Ontonagon River, has a considerable water power available which has been utilized in a novel manner. Distance from source to points of application is not great and the power for both mine and mill is distributed by compressed air. Moreover, the falling water operates directly on the air without the intervention of water-wheel or other machine.

Roughly speaking, this hydraulic air compressor consists of a large underground chamber cut from the solid rock and having a length of 281.5 ft., a width of 18 ft. and a depth of 26 ft. In normal operation the lower portion of the chamber is filled with water to a level of 14.5 ft. from its roof. The remainder, having a capacity of over 80,000 cu. ft., is filled with air at 114 lb. gauge. The water outlet is through a tunnel 18 ft. wide and 10 ft. high, the bottom of the tunnel being a continuation of the horizontal floor of the chamber. This tunnel opens into an inclined shaft about 18 x 20 ft. in cross-section, the discharge level of which is 271 ft. above the water level in the chamber. The outlet for air is a 24-in. pipe leaving the chamber through the roof directly above the tunnel outlet.

The inlet for both water and air is through three vertical shafts, each 5 ft. in interior diameter, opening through the roof of the chamber at the end opposite to the outlets. Each shaft is tightly lined with concrete, and is continued down into the chamber by means of a somewhat flaring steel casing to a distance of about 15 in. below the water level. Just beneath, and reaching somewhat into the opening of the casing, is a conical boss of concrete. From the water level in the chamber through the air and water-tight shaft to the water level at the intake above is 343 ft. This is 72 ft. greater than the distance between the water levels at the outlet end, and this difference expresses the available head of water.

At the intake water is admitted through an annular funnel over a hollow ring from the flat inner periphery of which project 1,800 ⅜-in. tubes into the annular opening of the funnel. The water must flow over the mouths of these tubes, and in doing so it produces the aspirating effect which entrains the air in small bubbles. The air comes mainly through the tubes from the hollow ring which has suitable intake pipes extending above the water level. The mixed water and air fall through the vertical shaft, and are discharged radially from the annular outlet formed by the concrete boss and steel casing below. The current through the chamber is slow, and the air disengages itself, collecting in the top of the chamber, and displacing the water. By its pressure on the water surface in the chamber it maintains the 271 ft. of difference in level between that surface and the one at the discharge of the outlet shaft.

While running at less than full capacity the water level in the chamber is prevented from being depressed further than 14.5 ft. from the roof by means of a blowoff pipe, 12 in. in diameter, which opens somewhat below the normal water level. When the water has been pushed down sufficiently air enters this pipe, and its escape relieves the excess of pressure. When the blowoff is in operation the appearance at its mouth greatly resembles the eruption of a powerful geyser. The stream of spray, due to the entrance of water with the air from the chamber, is thrown sometimes to a height as great as 400 ft.

The capacity when all intake shafts are operating is about 5,000 h.-p. So far but one intake is used. This under test at near its maximum capacity showed an efficiency of better than 82 per cent. while delivering 11,930 cu. ft. of air per minute at 128 lb. absolute pressure.

All machinery at the stamp mill and at the mine, whether on the surface or underground, is operated by compressed air. Beside utilizing cheap power the compressor has obvious advantages over the usual machine in the absence of parts to get out of order and in low cost of attendance.

The foregoing examples are presented to Section D as illustrating the type of problems which are arising in connection with the extensive operations at great depths on the low-grade lodes of the Lake Superior copper district.

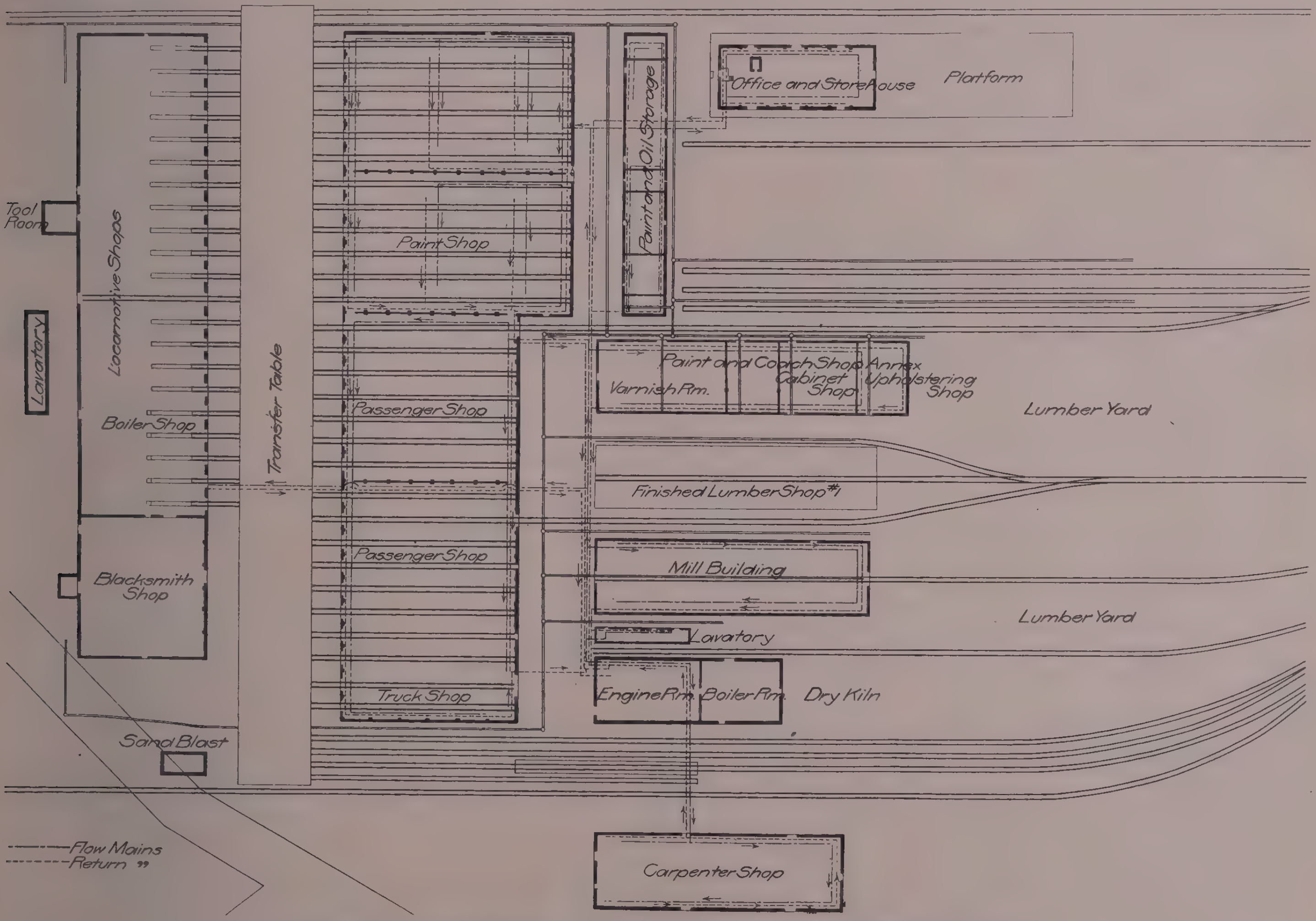
F. W. MCNAIR.

MICHIGAN COLLEGE OF MINES, December, 1906.

THE TRANSMISSION VOLTAGE of the Grand Rapids-Muskegon Interurban Electrical Ry. line has been increased from the former maximum of 60,000 volts to nearly 70,000. The voltage was first raised to 66,000 volts and operated at that pressure for about six months and subsequently raised to 69,000 volts, at which pressure it has now been under successful operation for some time.

Heating System of the Kingsland Shops of the Delaware, Lackawanna & Western R. R.

For heating the buildings of the extensive locomotive and passenger car shops of the Delaware, Lackawanna & Western R. R., at Kingsland, N. J., a central station system of the hot water circulation type was adopted after an extensive investigation of the advantages of both steam and hot water heating with various combinations of direct and indirect radiation. Owing to the installation of the extensive power system at the shops, described in The Engineering Record of Jan. 5, and to the desire to utilize the exhaust steam produced there, the Evans exhaust hot water heating system with forced circulation was adopted, which has closed tube water heaters at the central power plant, turbine pumps for circulating the water to and from the buildings, and combinations of direct and indirect radiation in the various shop buildings. Experience with a system of this character, installed at the Boston Navy Yard, which was described in The Engineering Record for July 16, 1904, indicated that the shop buildings might be thus heated with a minimum of equipment and expense in operation, the arrangement of the system providing adequate direct radiation for all ordinary heating and indirect radiation with fan systems for increased capacity necessary for quick heating and in extreme weather.



Arrangement of Buildings and Heating Mains at the Kingsland Shops.

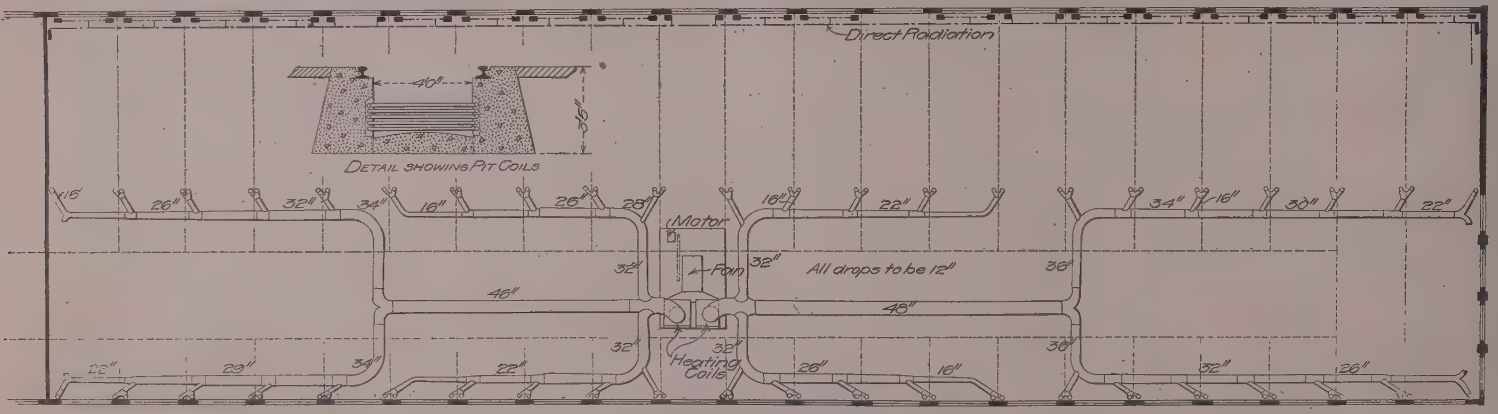
The heating of the buildings of this plant proved a difficult problem owing to the unusual amounts of window glass for day lighting, and also the large number of door openings attendant upon the transfer-table type of shop arrangement; the buildings are laid out on the cross-track principle with a transfer table between them by which cars are delivered to the passenger car shops by any one of 29 tracks, and the large door openings provided for the entrance of cars present the most favorable conditions for air leakage. The site is, however, sheltered somewhat by hills to the north and west, and favorable conditions are introduced by the best possible character of building construction. The seven buildings to be heated include the passenger car repair and paint shop, 170 x 660 ft. in size; the paint and cabinet shop annex, 70 x 300 ft.; the paint and oil storage building, 40 x 270 ft.; the mill building, 70 x 264 ft.; carpenter shop, 50 x 130 ft.; and the office and storehouse, 60 x 150 ft. in size; to this will soon be added the new locomotive erecting and machine shop, 126 x 606 ft., which is at present nearing completion. The buildings are all of steel and concrete construction, with brick curtain walls and heavy reinforced concrete roofs. The total cubical contents of the building heated is nearly 10,000,000 cu. ft., for which a total of about 50,000 sq. ft. of direct radiation has been installed, and indirect equipments capable of handling 200,000 cu. ft. of air per minute.

The hot water heaters in which the circulation water is warmed by exhaust or live steam, and the turbine pumps which are installed in duplicate for the forced circulation of the hot water through the flow and return mains and the radiation in the various buildings, are located in the power plant described in the previous article. The exhaust steam heater, which is a closed tube water heater, is installed at one side of the engine-room convenient for connection to the exhaust steam system at the rear of the engines. The circulating equipment consists of two turbine pressure pumps, one of which is driven by a De Laval steam turbine, and the other by an electric motor. They are located adjoining the heater and connected into the circulation system, with by-passes to permit either one being cut out as desired. The hot water circulation pipes are arranged in the basement, extending to the front to the point of entrance to the piping and wiring tunnel through which connection is made to the various shop buildings. There is also installed for reserve heating capacity a live-steam water heater of the closed tube type, for use when the engines and air compressors are not in operation or the supply of exhaust steam may happen to be insufficient. This tank is mounted in an elevated position at the division wall end of the engine-room, and is supplied with steam from the high-pressure auxiliary main, located on the opposite side of the division wall, having a 2½-in. condensation return connection. The water circulation system is similarly connected to this heater in series, with by-pass connection for cutting it out of service when not in use.

As stated in the article descriptive of the power plant, the exhaust piping connections of the plant are so arranged that any engine unit may exhaust into a line running to the hot water heater, or to one connecting with the condenser for operation under full vacuum. In this manner it is possible to adjust the amount of steam delivered to the water heater exactly to that necessary to balance the heating. By means of a connection from the water heater to the condenser for removal of condensation and air, heating will always be accomplished under vacuum, the amount of which will be under positive control. The system is designed for comparatively low temperatures, however, and adequate heating may be accomplished by the exhaust even when under considerable vacuum. The design of the system is such that, under ordinary operating conditions, the circulation water is discharged into the flow line at temperatures ranging between 150° and 170° Fahr., according to the outside temperature, and, furthermore, it loses but 10° to 12° in making the circuit through the radiation in the buildings. With the engines operating under a vacuum of from 15 to 20 in., temperatures ranging from 165° to 175° will be available in the hot-water heater and still the steam-using machinery will receive the benefit of condensing operation. Provisions for rapidly increasing the temperatures of the circulation water are made available by the live-steam heater, which is also of service in starting the system and for operation at night and on holidays.

The exhaust steam system is also arranged so that it may be operated non-condensing, either in whole or in part, by means of a back-pressure valve in the 18-in. exhaust header above the hot water heater connection, which enables the exhaust of any one engine to be turned into the heater at atmospheric pressure and benefit from the higher temperature of the steam therefore secured; or, if desirable, the entire equipment of engines in operation may be exhausted through the heater to atmosphere. In this way almost any combination of circumstances may be met, after the system is once started in operation, by adjustments of the exhaust system so that recourse to the live steam heater need be had only in emergency.

The exhaust steam system consists of two exhaust headers in duplicate, one an 18-in. and the other a 16-in. line, into which each of the generating units and the air compressors has a duplicate valved connection. The 18-in. line serves as the atmospheric connection, having no direct connection to the condensing equipment; it leads at one end to a 16-in. valved connection to the large exhaust hot-water heater ending beyond in a 16-in. atmospheric exhaust riser with relief valve. The 16-in. line is intended for condensing operation, connecting directly to the condensing equipment and having a relief connection into the atmospheric exhaust header through a back-pressure valve. It is the intention that ordinarily the entire system will be operated condensing by exhausting into the 18-in. line and passing the exhaust through the heater and back to the condensers through an auxiliary connection to the 16-in. line, but the connections to both lines are so flexibly arranged that any part of the equipment may be operated condensing and the remainder non-condensing, as may best suit the requirements of the service.



Hot Blast Heating Apparatus in the Locomotive Shop Building at the Kingsland Shops.

The arrangement of the water circulation mains in the yard is indicated in the accompanying plan of the buildings. The flow and return lines are carried underground throughout, in a system of piping and wiring tunnels which extend from the power plant to all the buildings of the shop system. The main tunnel extends cross-wise of the yard from the northerly end of the power house along the fronts of the mill building and passenger car shop annex and ends at a point between the paint shop and the paint and oil storage building. From this trunk tunnel three branches lead northward to supply the larger buildings, two to the passenger car repair shop and the other extending under the passenger car shop to the new locomotive shop, while at the easterly end of the tunnel, a branch leads in either direction, one to the paint shop and the other to both the paint and oil storage building, and to the office and storehouse beyond. The carpenter shop of the building department, to the west of the power house, is supplied by an independent tunnel connection extending under the yard tracks from the westerly side of the power house directly across to that building.

The flow line supplying the radiation in the various buildings is a large main extending to all of the buildings with branches supplying the radiation in each, while the return lines are brought back to the power house separately from certain buildings or groups of buildings, in order to provide means of control of the rates of flow to different sections of the plant. For this purpose, the plant is divided into six sections; the passenger car repair shop, the paint shop and passenger car shop annex, the locomotive shop, the mill building, the carpenter shop, and a group comprising the paint and oil storage building and the office and storehouse building. The flow line extends from the power house in the large trunk tunnel from which separate branches are taken off to supply radiation in the passenger repair shop, the paint shop, the locomotive shop, the mill building, the carpenter shop and a group of three small buildings. The independent return lines in the various sections are of size similar to the flow lines supplying them and similarly arranged. For the control of rate of flow in these various sections the separate return lines connect in the power house through adjusting valves to a suction header from which the return connection is made to the turbine pumps; by proper adjustment of these valves the rate of flow and consequent temperature conditions in the various buildings may be regulated.

The radiation has in general been distributed to counteract the window glass exposure directly, except in the paint shop, where additional radiation is installed throughout the center of the building to provide the higher temperatures necessary for paint drying. Typical arrangements of the radiators, which are manifolded coils of 1¼-in. galvanized pipe, are indicated in accompanying engravings. In spite of the greater amounts of heating surface that are required than in steam heating, convenient arrangements of coils have been secured in many cases by encircling the windows either in part or wholly, by which the radiation is brought in close proximity to the upper and lower tiers of windows. In the design of the system, the average ratio of heating surface to cubical contents for all the buildings is approximately 1 to 200. This ratio is, however, increased in a number of buildings where the conditions warranted it; in the paint shop where extra heating was desired to facilitate the painting and drying of cars, it was increased to 1 to 50, and in other departments to 1 to 100.

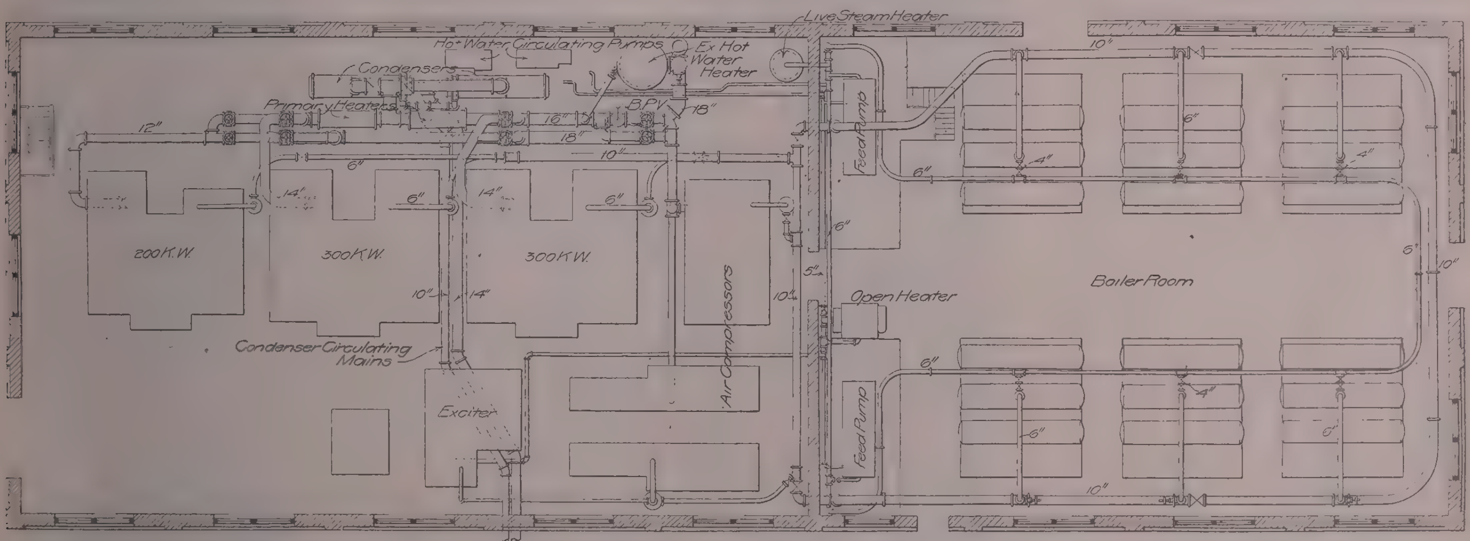
Indirect heating has been provided in four of the buildings, the passenger car repair shop, the mill building, the carpenter shop and the locomotive shop now under construction. This form of heating was found undesirable in the paint shop owing to the possibility of agitation of dust by the air circulation and attendant damage to freshly varnished surfaces. In all of the smaller buildings, direct radiation is depended upon entirely. The indirect systems are not installed for ventilation, but merely to provide greatly increased heating capacity when needed, air being recirculated from within the buildings in all cases. The indirect equipments are in all cases installed in the monitors and have intakes through heating stacks at those points, the purpose being to draw in air from the upper portion of the building which is always the warmest, and recirculate it after superheating to a higher temperature. For a given amount of radiation, the most effective results would be secured in this manner, and hence it was decided to thus utilize the large amounts of reserve radiation which were found necessary for quickly heating up the shop in the mornings and for use in extremely cold weather.

Extensive blower systems are required for the locomotive and passenger car repair shops, both having fans of 70,000 cu. ft. capacity. These are fitted with heating stacks containing 8,500 sq. ft. for the locomotive shop and 6,500 sq. ft. for the passenger shop. The mill and carpenter shop have systems of 15,000 cu. ft. capacity each, with heating stacks with 2,000 sq. ft. of surface in each case. The blowers are all of the full-housed, horizontal-discharge type, built by the American Blower Co., that in the locomotive shop being a 160-in. fan driven through belting by a 40-h.-p. induction motor, while that in the passenger car shops has a 13x96-in. wheel and is belt driven by 40-h.-p. induction motor. The units in the mill and carpenter shop are 80-in. fans driven through silent-chains by 5-h.-p. motors. The fan equipments are all mounted on platforms hung from the roof trusses, so located as not to interfere with the lighting of the shop. The motors are operated from starting boxes near the floor, and as the heating stack connections are accessible from below, the equipments are controlled from the floors of the shops with ease.

The indirect equipments have in all cases simple duct systems with branch outlets in all parts of the buildings for a uniform distribution of the warm air. All fans are centrally located in the buildings and from them large cylindrical trunk ducts extend in either direction, with branches to either side. The branches are 10 and 12-in. ducts, and the outlets are carried down to points 10 to 12 ft. above the floor. The systems are proportioned for re-handling the entire contents of the buildings every 30 to 40 minutes when operated at maximum capacity. They may, however, be operated at part speed as required. The duct delivery systems are designed for comparatively high velocities, ranging from 1,000 to 1,500 ft. per min., but the velocities are reduced considerably at the outlets.

The indirect systems are intended only for heating in extreme cold weather, or for rapidly bringing the shop buildings up to working temperatures in the early morning. They are not used at night, and are in all cases shut down when the outdoor temperature rises above 30° Fahr., above which temperature, the direct radiation is of ample capacity to accomplish the required warming. This arrangement of heating, embracing both direct and indirect radiation, was selected as being capable of more efficient adaptation to different weather conditions than any other. It is found when the outside temperature is below 30° Fahr., that heating can be accomplished much more effectively and economically by the indirect system, while for the higher temperatures the direct radiation works to better advantage.

Among the more important advantages with this design may be noted the fact that the exhaust steam is all disposed of at the central plant and that all engines exhausting into the hot-water heaters operate at a vacuum corresponding to the outboard temperature of the hot water delivered to the radiation. By means of the exhaust piping connections, the exact quantity of steam required for warming can always be furnished by some one engine or group of engine units, while all other engines not required in the heating system may be operated condensing at full vacuum. The amount of auxiliary exhaust steam produced may be kept down to the minimum quantity necessary to raise the feed water in the open heater from the temperature of the primary heaters to 212°. The proportions of direct and indirect radiation provided in the shop buildings enable the direct radiation to care for the night and holiday heating, so that the blowers may be run by motors and still not incapacitate the system when the main generators are shut down. The proper distribution of the direct radiation assists the air from the fans to diffuse thoroughly at low temperatures, and at the same time the use of the blowers of large capacities enables effective heating to be accomplished with lower temperatures of the water. The blowers have intakes near the roof line and therefore draw in the warmest air from the buildings, and, distributing the same, maintain more nearly uniform temperatures throughout the building, there being normally in the buildings a difference of temperature between floor and roof levels of not over 2°; this results in preventing to a large degree the excessive heated conditions near the roof line with resulting increased exterior radiation from the walls and roof.



Details of Exhaust Steam Piping and Hot Water Heating Apparatus in the Kingsland Shops Power Plant.

The heating system of the shop plant, together with the attendant piping systems and auxiliary equipment of the power plant, was designed and installed by Evans, Almirall & Co., New York, in conjunction with the engineering department of the Lackawanna R. R. Of the latter department, Mr. L. Bush is chief engineer, and Mr. F. J. Nies is architect. Mr. I. N. Evans was engineer for the contractors.

A New London Underground Railway.

Another tube railway has been opened recently in London by the Underground Electric Railways Co. It is 9¾ miles long and connects Hammersmith with Finsbury Park. There are two circular tunnels each 11 ft. 8 in. in diameter on tangents, 12 ft. on curves with a radius not less than 10 chains, and 12 ft. 6 in. on sharper curves. The diameter of each station tunnel is 21 ft. 2½ in. The tunnels have been driven through clay and are lined with cast-iron segments. The depths below the street level vary from 29 to 123 ft., but the gradients are not severe except at the stations where there are retarding grades of 1 in 66 for approaching trains and accelerating grades of 1 in 33 for departing trains. The usual radius of the curves on this line, which is known as the Great Northern, Piccadilly & Brompton Ry., is 132 ft. The track construction includes a concrete base narrower than the length of the ties so that the ends of the latter which carry the rails extend beyond the foundation and give a certain amount of elasticity. The rails weigh 90 lb. per yard and the chairs 30 lb. each, lag screws being used to secure the latter to the non-inflammable karriwood tie, with a layer of pressed wood felt between the two. The electric current for the operation of this line is generated at the Lots-road power station at Chelsea, described in this journal on Feb. 25, 1905. The tunnels are ventilated by nineteen motor-driven exhaust fans, each 5½ ft. 6 in. in diameter, and each drawing out of the tunnel 18,500 cu. ft. of air per minute. The Westinghouse electro-pneumatic automatic signal system is used and signals are provided with Adlake long-burning oil lamps, which require attention only once a week. There are on the line eighty-four signals which will automatically apply the brakes to the train in case the motorman does not heed his stop signal.

The Artistic Treatment of Concrete.

Paper presented before the National Association of Concrete Users by Mr. A. O. Elzner, of Elzner & Anderson, Cincinnati, Ohio.

The consideration of concrete from an æsthetic point of view may strike the average cement user as inappropriate and impossible, for hitherto the term "concrete" at once suggested foundations, piers, dams, abutments, and, nowadays, it more than likely calls to mind columns, beams, floors, walls, and, in fact, the entire structural parts of buildings. But it must be evident that our experience with this new material, new only, however, in the sense of adaptation, will show that like all legitimate and substantial structural materials, it, too, will prove to be susceptible of artistic treatment in design. Wood and stone architecture are as old as the hills, and the art of the mediaevalist in developing true styles with these humble materials rightfully belongs to the world wonders. Brick and terracotta can scarcely claim quite so much distinction, although in point of artistic treatment they were brought to high development in the Gothic art of Italy. Iron and steel, however, do not fare quite so well except in a small way along the lines of purely ornamental work; for when the modern rolling mill began to turn out its product of structural shapes, and engineers discovered the wonderful possibilities of riveted sections and connections, there was a great rush for structural iron and later for steel. Everything imaginable was made of it and more in Europe than here. Bridges and viaducts, certain classes of business blocks and public buildings, even churches and cathedrals, all vied with one another in their architecture of iron and steel, and while some notable attempts achieved a measure of success, it required many years to develop an artistic style of design. And even at this late day, structural engineers as a class seem determined to ignore the application of æsthetic principles to their designs of exposed work.

But we feel quite hopeful. There has been and is much teaching and preaching of æsthetics. Schools, periodicals and municipal art societies are doing much to educate the popular taste and to create a demand for beauty in public works, and this campaign, whose influence is spreading rapidly, will undoubtedly bring designers to recognize and appreciate the necessity and propriety of combining beauty with utility in all visible constructions.

This problem will be greatly simplified in concrete work; for here, for the first time, we come to deal with a plastic material which can be moulded and modeled at will. Beauty, however, in structural design is worthy of the name only when, like beauty in nature, it has character. It must not be a servile copy of the style peculiar to some other material, but in fact must express the individuality of its own nature and must not dissemble.

It is just this peculiarity that we must be careful of in our concrete block architecture. At present the tendency in the manufacture of these blocks is to imitate split faces of stone ashlar. This is radically wrong in principle and should not be tolerated. A flat, smooth face will always look well. However, if a pitched or split face is desired, let it be produced by casting the block flat and then pitching off the face with chisel and hammer just as is done with stone. The clean fracture of the concrete thus exposed will be eminently effective and artistic and will have all the merit that belongs to truthfulness. Plain concrete ashlar walls might in some cases be effectively relieved by the introduction of bands of decorated blocks with some simple ornament moulded in the face, very much as is done with terracotta, but by all means avoid molded rock-faced work. It is artistically bad. The frequent and constant repetition of a few regular sizes and patterns, ruins an effect which should be counted largely as accidental but always expressive of a fine artistic sense in the selection and grouping of the individual blocks. Artificiality, imitation and misrepresentation are stamped all over such work and can be recognized at first glance.

Solid concrete walls have a great advantage over the block walls in that they lend themselves much more readily to artistic treatment. This is especially true where they are used in suburban and country buildings, perhaps because of the touch of nature in the surroundings which more nearly accords and harmonizes with the broad treatment that can be so effectively employed in wall surfaces. Perhaps the best sources of inspiration that can be had for such treatment are to be found in the old Spanish Missions of California, which, although not of concrete, nevertheless at once suggest its use and above all are fine examples of the artistic value of broad wall surfaces relieved by exquisitely proportioned openings judiciously spaced and not infrequently embellished by a moderate use of ornamentation.

Let us say then, speaking of domestic architecture, where walls are made of solid concrete, the surfaces should be as unbroken as possible, avoiding especially artificial jointing, of which such frequent use is made, obtained either by scratching a joint into the fresh mortar with which the surface is plastered, or after the removal of the forms, or by planting beveled wood strips on the inner surface of the forms, thereby molding the joint directly into the concrete.

Both methods are highly objectionable, utterly senseless and æsthetically very bad and should be shunned. In work of moderate cost, where effects are to be sought in an inexpensive, straightforward and natural way, there can be no offense taken if the concrete is left untouched after removing the forms. In fact, this method has so much merit, that it might with perfect propriety be classed as the most thoroughly artistic. That is probably just what the builders of the old Spanish missions would have done if they had had concrete to use for their buildings. To be sure, if such treatment is to be used, some care should be exercised in the preparation of the form work, so that it will not result in the effect of a lot of patchwork.

In more pretentious work several methods of treating the exposed concrete are available. A thin skin or crust of neat cement usually is found to cover the surface where concrete was deposited wet and was well tamped. This crust may be removed while still soft by means of a stream of water having some force, or by stiff wire brushes, in which cases the forms must be removed promptly and just as soon as the work will stand it. This, however, involves considerable danger and should be done only by thoroughly experienced persons. If successfully accomplished, the effect of the rough surface thus produced is good and consistent, for it exhibits the material in its true nature and avoids all semblance of artificiality.

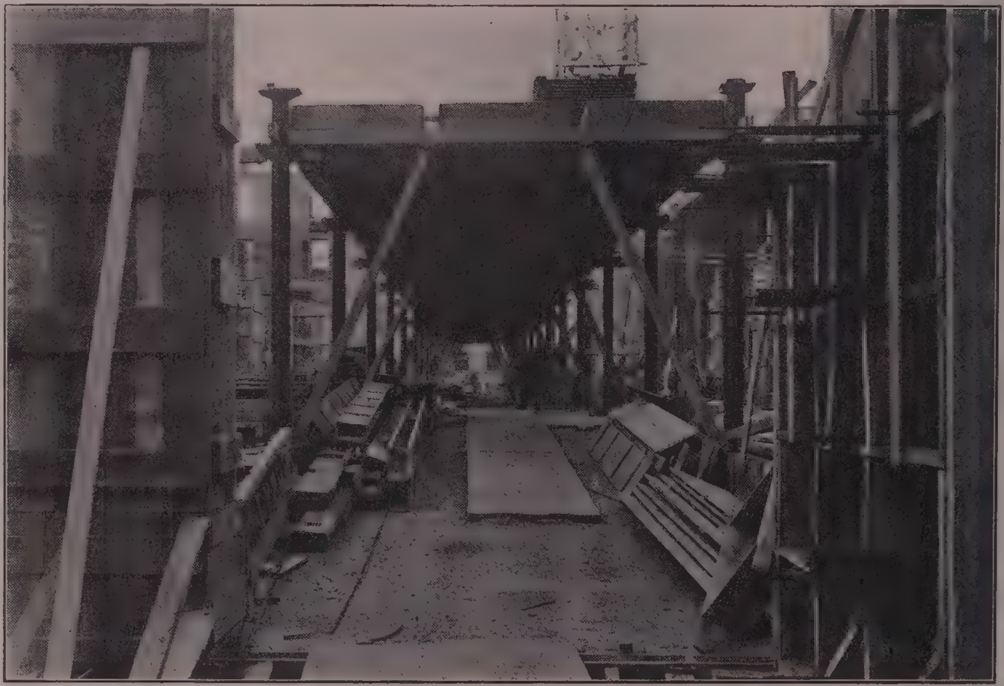
This treatment, however, entails so many difficulties that it will not be very popular, and it will be advisable to adopt some other simpler and safer method giving similar results. The surfaces can be tooled all over with a chisel, as in some classes of stone work, but while the result may be effective, it is rather expensive and slow work and will therefore be but sparingly used. It is difficult, too, to avoid loosening an occasional pebble or stone and thus spotting the surface with objectionable blemishes, and possibly opening up some internal cavities which are quite apt to occur and so starting a leak in the wall.

A simple and inexpensive, yet thoroughly practical method of securing an artistic effect, consists of covering the wall surface with a splatter-dash coat of cement mortar applied by splashing it on with a paddle or a broom, or better still, it may be first spread on with a trowel and then roughened by stippling with a stiff broom or brush or even a flat board, in which case the roughening is obtained by suction against the board. When such treatment as this is to be used it may be highly appropriate in some cases and indeed quite interesting to decorate parts of the surface with some simple panel work or freehand modeling. In case of panels, it is best and simplest to adopt sunken work, as this can be readily produced by merely planting a board or block of desired shape against the inside face of form work, which leaves its impress upon being removed from the concrete. Or else a reverse mold made of some artistic bit of carving for a panel, or over a door or window, or a frieze, etc., may be nailed against the forms, and the resulting impress will be thoroughly effective, although a much higher artistic value would be due such work if it were modeled by hand directly in the cement mortar as it is applied and before it has had a chance to harden.

This sort of work is being done extensively and successfully in Germany where the modern style of "Nouveau Art" presents abundant opportunity for endless designs. It is already finding much favor in our own country and ought to reach a high degree of development.

Moldings, especially in continuous courses, if attempted at all, should be of the simplest possible design; bold, yet of moderate projection and free from small delicate members. Square effects and beveled projections serve very well in the place of conventional molding and rather accentuate the character of the work and heighten its effect. Dentils of fair size can be worked in to good advantage and with comparatively little difficulty. Such work should, however, be used sparingly on account of the impracticability of treating the surface of the resulting small members, unless great freedom and latitude are allowable without detriment to the artistic character of the design. It is particularly difficult to do this in case the walls are to be plastered over with cement mortar. Where this is done, the work should be finished under the float rather than the trowel so as to minimize the tendency to crack or craze, a great source of annoyance and disfigurement. Trowel finish furthermore almost invariably produces a series of blotches of different shades and textures, which, if introduced into rough work, have much artistic value, but must be classed as nothing better than blemishes in smooth troweled surfaces. Moreover, it is extremely difficult and well nigh impossible in plastering over molding or projecting band courses, to keep the edges straight and true as they should be in smooth finish, with the result that the poor slovenly workmanship imparts an air of cheapness and flimsiness to the building instead of the reverse, value and substance.

Such then, are some of the readier methods that can be employed in producing artistic effects with concrete. This humble material, so replete with possibilities, but as yet so little understood, is manifestly destined to take an important place in the construction of our buildings and must therefore strongly influence their design. But it means long, continuous and close observance and study of its nature, its possibilities and its limitations. If our designers will devote themselves sufficiently to this subject, as it so well deserves, they will discover in concrete a new and useful friend, and with its help will evolve a new architecture, full of life and character, strength and dignity, and all else that goes up to make a living style.



Supporting Second-Floor Centers by Inclined Posts Independent of First-Floor Centers during the Construction of the Metropolitan Garage.

The Metropolitan Garage.

By A. Jordahl.

The Metropolitan Garage is one of the many reinforced-concrete buildings now being erected in New York City. It is located on a lot east of 7th Ave. between 49th and 50th Sts., in Manhattan, and covers an area of about 11,000 sq. ft. It will have one basement and four stories above street level. The building is being erected as a skeleton structure, with floors, roof, exterior columns and two interior columns of reinforced concrete. The balance of the interior columns were made of cast-iron to save floor space. All basement walls are rubble masonry, while the walls above the street level are of brick, which, on the two street fronts, will be stuccoed to give the appearance of an all-concrete building. The footings rest on rock, which was assumed to carry safely 10 tons to the square foot. The floors were designed for a uniformly distributed live load of 120 lb. per square foot.

One of the novel features of this building is the connection of the reinforced concrete beams and girders to the cast-iron columns. This detail, of which a sketch is shown, has been developed by Mr. J. O. Ellinger, of the Reinforced Cement Construction Co., who has applied for a patent on it. The main reinforcing bars of the beams and girders stop within about one inch of the face of the columns. In the latter four holes have been cored, parallel to the beams and girders. Through these holes four bars 6 to 8 ft. long are inserted, to act as an anchorage and also to take up negative bending moments at the columns. To protect the rods from corrosion, the upper parts of the column are filled with concrete, which is supported on a wooden bottom, suspended from the top.

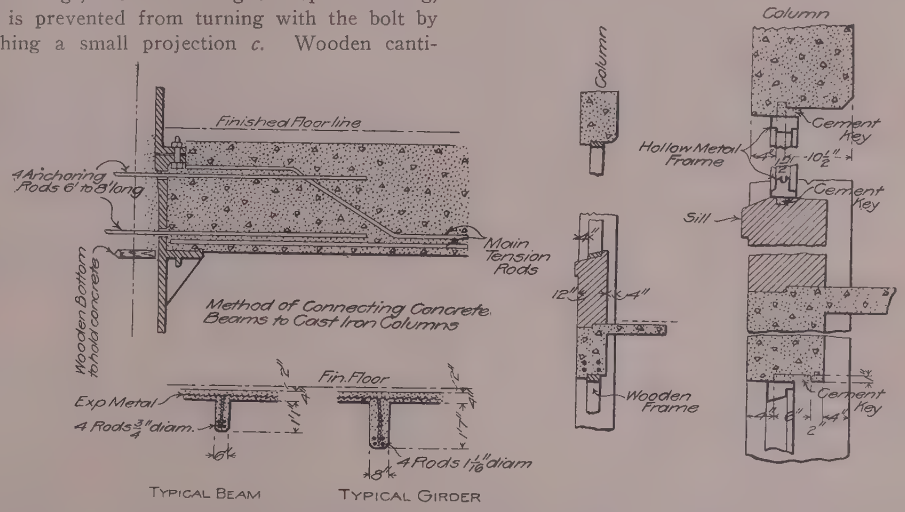
The wooden centering is shown in an accompanying cut. The sheeting for floor slabs is made of 1-in. tongued and grooved boards, planed on one side to ⅞ in. The sides of the beams and girders are made of 1¼-in. tongued and grooved stuff, planed on one side to 1⅛ in. The bottoms of the beams and girders, as well as the forms for the concrete columns, are made of 2-in. dressed planks, planed to 1⅞ in. All studs are 3 x 4 in., braced one way. The cast-iron columns have been used for the support and alignment of the centering, as shown in the cuts.

In this way at least two studs are saved for each girder and beam connecting to the columns, and in addition to this, quite considerable time is saved in erecting the centering, adjusting it to correct lines and levels and in removing it. The centering for the beams and girders is made up on the ground, nailed together into boxes, cut to lengths and provided with necessary battens, etc. The slab centering is put together in sheets, covering one-half of a bay.

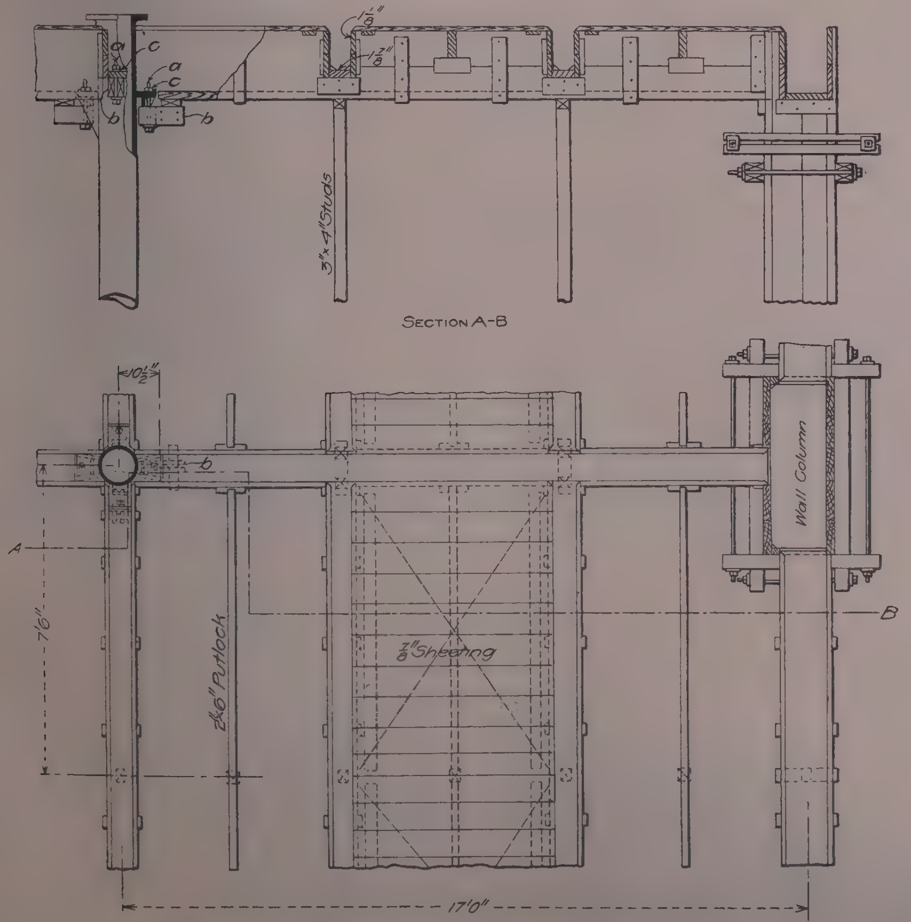
After the cast-iron columns are placed, the erection of the centering proceeds as follows: Suspension bolts *a* (see section A-B through centering) are inserted through cored holes in the column lugs, the nut resting on top of the lug, and is prevented from turning with the bolt by catching a small projection *c*. Wooden cantilevers, *b*, made up of three short pieces of board nailed together, are now inserted on the bolts, one end supported by a small cross-rib cast in between the main ribs of the lugs. The concrete column forms are erected next. These are kept slightly above the top of the floor slab to admit of being lowered a little when being taken down.

The girder boxes are now suspended between the columns, bearing with their bottom and batten directly on cantilever, *b*. The beam boxes between the columns are suspended in like manner and the other beam boxes supported directly on the girder boxes. The slab sheets are erected next, being supported at the sides and ends by the beam and girder boxes and in the center by a 2x6-in. putlock.

One 3x4-in. stud is now erected in the center of each beam and putlock, and two studs at the intersections of beams and girders. This completes the centering with the exception of oiling or soaping. To remove the centering, the column forms are taken down first, next bolts, *a*, in column lugs are unscrewed, the nut remaining in its place on the lug. The girder-beam-and-slab centering is then easily removed and is ready to be erected anew on a higher floor.



Details of Design of the Metropolitan Garage.



Details of Forms used in Metropolitan Garage.

The reinforcement used is the modified De-Valliere system. It consists, for the beams and girders, of four round rods, of which two are bent up at the ends to take care of shear and negative bending moments at the supports. In addition to this, a sufficient number of hangers or stirrups are provided to resist the horizontal shear. The reinforcement for the floor slabs is No. 9 expanded metal of 3-in. mesh, cut to such sizes at the mill that two sheets will cover one bay. The sheets are laid with 6-in. end-lap and 3-in. side-lap, the lapping sheets being wired together with annealed wire. The floors will be finished in cement 1½ to 2 in. thick, put on after the concrete has set.

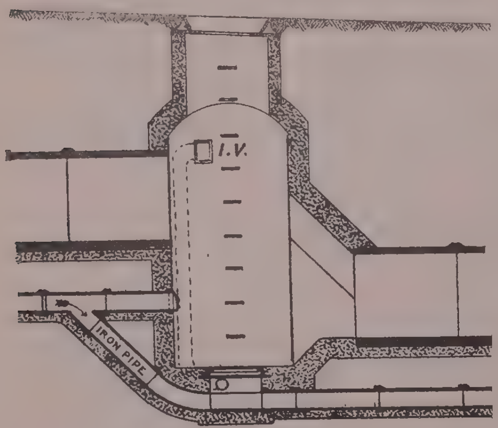
The windows in the two street fronts are wood, while those in the area walls are hollow metal. The method of securing the window frames to the concrete work is indicated in the accompanying illustrations.

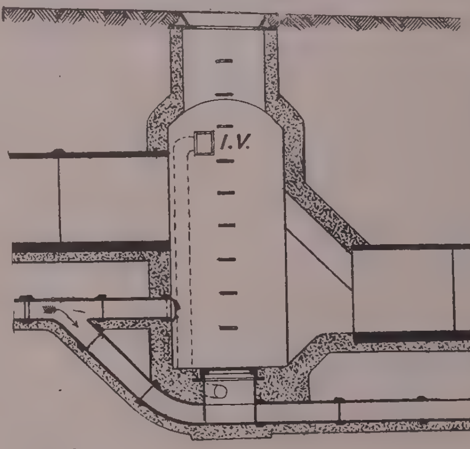
Mr. A. Namur is the architect for the building. The reinforced concrete work was designed and is being executed by the Reinforced Cement Construction Co., Mr. J. O. Ellinger, general manager. The writer had charge of the designing of the reinforced concrete work and other structural features.

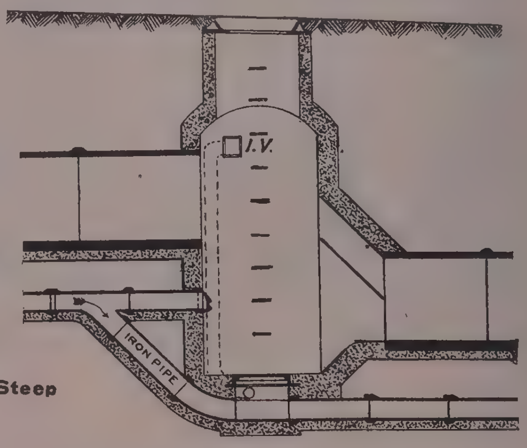
A 900-VOLT DIRECT CURRENT RAILWAY has recently been completed between Bonn and Cologne, Germany, using standard double-trolley overhead line construction and track-rail return.

Sewerage and Drainage in Johannesburg, Transvaal.

The city of Johannesburg, Transvaal, has a population of over 150,000, and is located on the top of a mountain with its culminating ridge running east and west. The municipal area is drained by five valleys or spruits running from the ridge. The Fordsburg Valley, running to the southwest, drains the largest and most important section of the city, 14,000 acres in area. Next in importance are the eastern and southeastern districts, 4,600 and 9,000 acres in area, respectively. The Fordsburg Valley area has been provided recently with both sanitary and storm-water sewers, and work on similar systems, for the other districts mentioned, is in progress. In determining whether a separate or combined system should be used, several factors, not usually present, affected the decision. The rainfall is seasonal and for five months in the year will not be available for flushing the sewers. The nature of the ground and the high grades allow flood water to run off very rapidly, and the volumes to be handled are large. In the past, the mines have arranged to catch and use a large part of this water, and they will probably continue to do so in the future. A combined system would require large sewers, through which, during a great part of the year, only a small amount of sewage would flow. Moreover, if the storm water ran through a combined system it would be mixed with domestic sewage and made unfit for use at the mines.





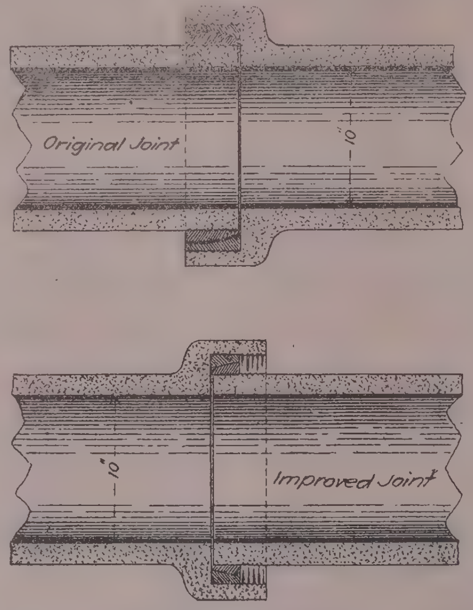


Sanitary and Storm-Water Sewers on Steep Grades in Johannesburg.

Except where spruits occur elsewhere, the storm-water drains have been laid in the streets. Most of the excavation is in rock, and, as a matter of economy, the sanitary and storm-water sewers are placed in the same trench, the former being below the latter. The storm-water sewers have been laid to fairly steep grades, so as to increase the velocity of flow and thus decrease the size of the pipes as much as possible. For connections to gutters, and for drains up to 10 in. in diameter, glazed stoneware pipes, with bell and spigot, are used. For pipes 12 to 40 in. in diameter, reinforced concrete is found usually to be most economical, while for the largest conduits, concrete or rubble-masonry channels, either open or covered, are used.

The probable future population per acre, in the various sections of the city, was estimated on the basis of past experience in Johannesburg and on data drawn from other towns whose conditions are somewhat similar. Ten to forty persons in residential districts, sixty in completely built-up urban sections, and seventy in the business section, were the densities of population per acre estimated for the future city. On the mining area, within the municipal boundaries, five persons per acre have been provided for. On the basis of these calculations 218,000 is reached, the future population of the district drained by the Fordsburg Valley.

Forty imperial gallons of sewage per capita have been provided for, the estimate being based partly on the experience of Melbourne and Sydney where, though provision was made for 75 gal., the actual flow did not exceed 40 gal., even though the water supply was ample. As Melbourne had a population composed almost entirely of white people, it is thought that 40 gal. per capita is a safe estimate for Johannesburg, where a considerable percentage are natives and Asiatics, who use less water than Europeans. The sewage has all the characteristics of ordinary domestic sewage and receives in addition a fairly large proportion of waste water from breweries.



The Stanford Joint.

In laying the sanitary sewers the aim has been to secure a self-cleansing velocity when running only one-quarter full, and, at the same time to avoid velocities high enough to cause erosion of the pipes. In general the velocity will not exceed 5 ft. per second. In most instances the sanitary sewers are not more than 6 or 8 ft. below the surface. It was not deemed desirable to excavate to a greater depth than was otherwise necessary merely to accommodate a few buildings whose basements are very deep.

The sanitary sewers, up to 12 in. in diameter, are of salt-glazed stoneware pipes, with bell and spigot. During the earlier stages of the work, all stoneware pipes were joined with cement mortar, but later a form of connection, known as the Sanford joint, has been used. The original joint as patented and the modification used at Johannesburg are shown in accompanying illustrations. The composition which, in the original form, fills the joint, is made of powdered earthenware, sulphur and tar. The curved form of contact, between the ring of mastic lining the bell, and that on the spigot, is said to admit of settlement without damage to the pipe. In the type used in Johannesburg the outer half of the joint is filled with cement mortar.

Sewers above 12 in. in diameter are of reinforced concrete. The pipes are made with bell and spigot and are joined in the same manner as those of stoneware.

All stoneware pipes are bedded in concrete to a depth of at least one-third their internal diameter. Concrete pipes are considerably stronger and are simply laid on a concrete bed.

No sewers smaller than 5 in. are used, and in the central district of the city, 6-in. pipes are required. House connections must not be more than 1 in. less in diameter than the sewer into which they discharge. As a rule sewers laid in the public streets are not tested, careful inspection being relied on to ensure good work. This course is adopted because of the delay caused by testing, and because of danger of injury to the green mortar in the joints.

Manholes and lampholes are depended on for ventilation and are provided with covers which can be closed if any nuisance arises. No provision is made for flushing as self-cleansing gradients have been secured. Placing the storm-water drain above the sewer has resulted in a saving of manholes and obviates the risk of sewage escaping into the street in case of a stoppage, since it runs into the storm-water drain instead. An accompanying illustration shows the relative arrangement of the two sewers and also indicates the method used in taking the sewers down steep grades by a series of steps.

The house drains depend on the discharge from closets, baths, etc., for flushing. As the Drainage By-Laws were passed when few house fixtures of this sort had been installed, it was possible to draft laws that would ensure good results, rather than fit existing conditions. A 2½-gal. closet is allowed if the gradient of the house drain is at least 1 in 35, if there is no intercepting trap, and if the rate of discharge is at least ½ gal. per second. If any of these requirements are not complied with a 3-gal. tank is required.

The disposal of the sewage of the southwestern district is accomplished about ten miles from town, where an irrigation farm of 2,643 acres has been acquired. About 1,900 acres are adapted for sewage disposal, both in character of soil and fall of the ground. The remaining area will be used as a location for natives, bazaar for Asiatics, a washing site, etc. Before the sewage is led onto the ground it is treated in septic tanks, from which it flows in open carriers to the irrigation plots. The main carriers have a sectional area of 4 sq. ft., and a fall of 1 in 700. There will be about 16⅓ miles of main carriers according to Messrs. D. C. Leitch and G. S. Burt Andrews, from whose paper on "Sewage and Storm-Water Drainage in Johannesburg," published in the "Journal" of the South African Association of Engineers, these notes have been taken. It is considered that with a soil as favorable as this, one acre will suffice for the sewage of 100 persons, without septic treatment. With septic treatment one acre will probably be sufficient for 250 persons.

The gravity outfall sewer from the city to the septic tanks is 9¼ miles long, and consists of an egg-shaped concrete sewer, iron pipe, and concrete-lined tunnels. Provision is made for additional sewage which may enter the sewer at points along its length. There are two tunnels about 1,827 and 5,611 yd. long, respectively. The longer lies at a depth of 111 to 240 ft., and has a cross-section of about 14.6 sq. ft. It was driven through rock from both ends and from eighteen intermediate shafts. For a distance of 750 ft. the sewage is carried in the shorter tunnel, in an 18-in. iron pipe laid on the floor at a greatly increased grade. This was done on account of neighboring mine workings from which the sewer may be subject to settlement. Expansion joints are provided which allow of lateral or vertical movement.

Windmill Electric Plant Requirements.

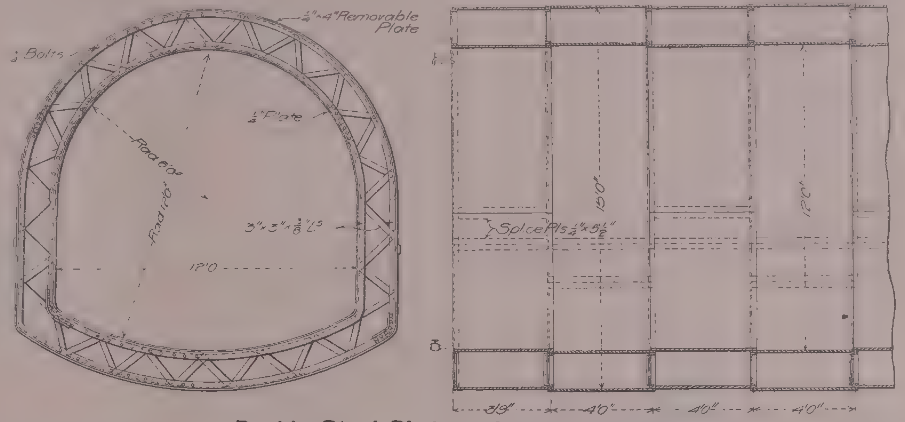
The essentials of a windmill electric plant have been stated by Mr. W. O. Horsnaill, of England, as follows: First, to ascertain the averaged daily load in ampere-hours during periods of maximum current consumption; second, to provide a storage battery of a capacity at least double this output; third, to install a dynamo of sufficient capacity to charge this battery in 12 hours; fourth, to design the dynamo to deliver an approximately constant voltage throughout a wide range of variation of speed; fifth, to erect a windmill of ample size to run the dynamo at full load with a ten-mile-an-hour wind, and sixth, to fit the windmill and driving gear to the dynamo with ball or roller bearings throughout to eliminate friction. A large number of plants built to these specifications are said to be in successful operation.

Condensation Water Intake and Tower Foundations, New Waterside Station, New York Edison Co.

The new Waterside power plant of the New York Edison Co. is located on the shore of East River, at the foot of 39th St., and is connected by bridges and tunnels with a steel coal and ash tower about 25 ft. wide, 105 ft. long and 230 ft. high, which with its maximum contents has a total weight of about 1,600 tons and is located with its longitudinal axis parallel with and about 20 ft. from the bulkhead line. This concentrates a very heavy load on the bulkhead and on account of the great height of the tower, the machinery installed in it and the connection with the main building about 90 ft. distant, great pains were taken to insure the stability of the foundation, which was made integral with the bulkhead construction. The latter is substantially of the standard type adopted by the Department of Docks and modified somewhat to conform to the special requirements of the case.

Concreting Intake Tube: Derricks and Concrete Plant in Background.

At this point, the river has a depth of about 24 ft. at mean low water and its bottom is nearly 50 ft. above the surface of the rock. The piles on which the bulkhead and tower foundations are carried were driven through old crib and stone foundations that had been built for many years and were thoroughly settled and well silted with material filled in and deposited by the action of the water. The piles were driven to a satisfactory refusal, penetrating not more than an inch under the last five blows of the hammer, thus giving an average length of about 65 ft. up to mean low water where most of those not directly supporting the sea wall were capped with a timber grillage. Others were cut off at a lower level to receive the sea wall masonry and to support the condensation water conduits. Cobble stones and riprap were deposited around the piles as indicated in the cross sections and the spaces between the riprap and the grillage platform were back filled with earth. The width of the grillage varied according to the requirements of the foundations and was a maximum for the tower foundations. Beyond them it had a total width of only 21 ft. extending about 16 ft. beyond the inner face of the concrete backing for the sea wall and was there covered with the standard fill and pavement of the city piers. The sea wall was built up to the grillage platform with concrete blocks having a maximum weight of about 70 tons each. These were cast in wooden moulds and handled by a floating derrick which lowered them to the pile tops, where their position was adjusted and verified by divers. The concrete was faced with dimensioned granite extending 2½ ft. below low-water line and bonded into the concrete backing as indicated in the cross-section.

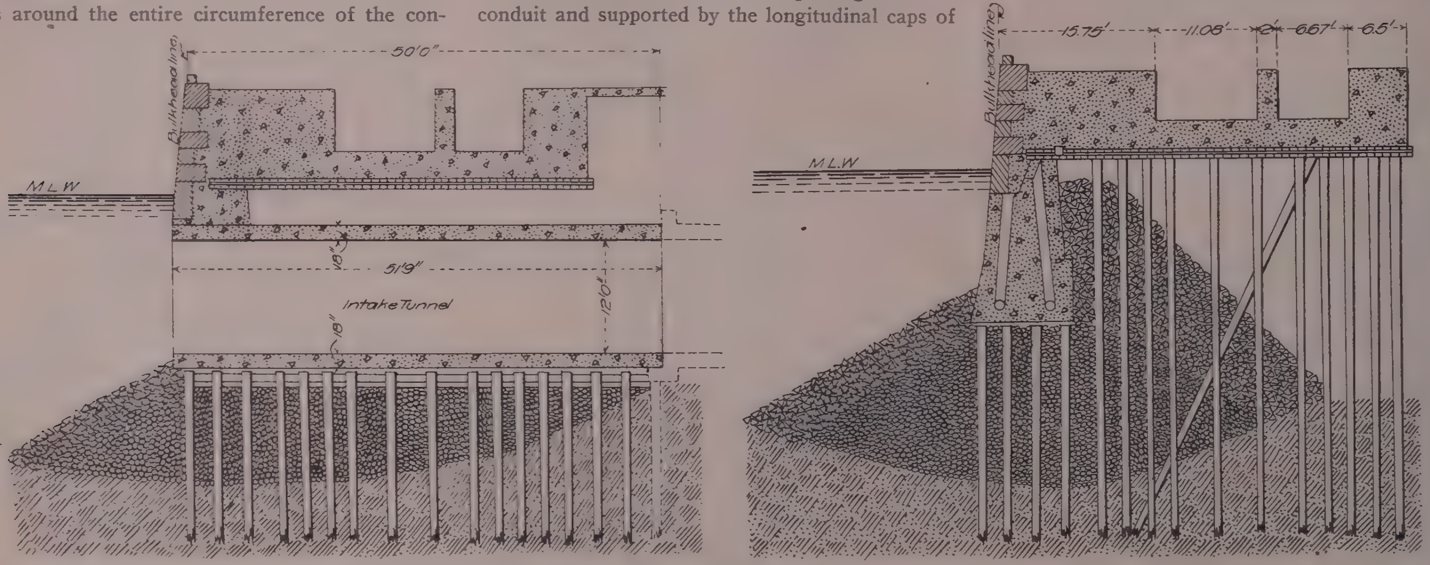


Double Steel Shell of Intake Conduit.

The tower foundations are a monolithic mass of concrete about 43 ft. wide and 115 ft. long over all with a depth of 8 ft. except where reduced under the center of the tower and over the intake conduit. It is reinforced throughout by two crossed tiers of 1¼ in. round bars 6 in. apart. The total amount of concrete contained in the foundation is about 1,100 cu. yd. It was made 1:3:5 with Helderberg Portland cement mixed in a Ransome machine located on shore near the middle of the foundation and handled in 1-yd. Stuebner buckets delivered from the machine to the point required by two stiff leg derricks with 63-ft. booms. No. 1 derrick was permanently located opposite the middle of the bulkhead at one end of the tower station. No. 2 derrick occupied two positions, the first one 75½ ft. distant from the No. 1 derrick so that the two commanded the entire area of the tower foundation as well as the cement shed and concrete mixer, thus serving for all the foundation work and commanding the intake conduit. After the tower foundations were completed, No. 2 derrick was moved to the opposite side of No. 1 derrick and with it commanded the remainder of the bulkhead work and the discharge conduit.

The condensation water used in the power plant is received through an intake conduit passing through the bulkhead wall and one end of the tower foundations. After being used, it is discharged through a similar conduit passing through the other end of the bulkhead wall beyond the tower foundation. These conduits are substantially duplicates and are built for most of their length with concrete cast in moulds in open cofferdams. Where they pass through the bulkhead and sea wall, this method of construction was impracticable on account of the impossibility of excluding the water from the bottom of the enclosed area and the difficulty of driving sheet piles to form the sides of the cofferdam. The outer ends of each conduit were therefore made with steel and concrete tubes about 50 ft. long, built on shore and sunk into position on foundations previously prepared for them on the bulkhead and foundation piles. After being thus set, the bulkhead wall and tower foundations were built over them and the shore ends were connected with the concrete portions of the conduit already mentioned.

The intake has a horseshoe shape cross-section 12 ft. wide and 12 ft. high inside and is made with double steel shells ¼ in. thick and 18 in. apart. The plates are riveted together in rings 4 ft. wide with 3 x 3-in. angle ribs covering each transverse joint. The longitudinal joints are spliced with single-cover plates. The inside and outside transverse joints are in the same transverse planes and at every other panel point are connected by 3 x ⅜-in. lattice bars continuous around the entire circumference of the conduit. Each angle ring was made in four pieces spliced with bent angles at the lower corners and with cover plates at the upper corners. The shells were built by the Cunningham Boiler Works, Brooklyn, where they were completed except that the top plate 4 ft. wide was removeably secured to the outer shell from end to end with ⅝-in. tap bolts. All other joints were riveted up and those in the outer shell were thoroughly calked.



Intake and Tower Foundation and Bulkhead Wall.

Both ends of the conduit were closed with solid bulkheads of 6 x 12-in. vertical planks stiffened with 12 x 12-in. horizontal and vertical inside beams braced to the inner shell. The planks extended across the flanges of the outside shell and were securely bolted to them with rubber gaskets and their seams were calked with oakum. Each conduit weighed about 40 tons, was assembled on blocking close to the edge of the pier, and when completed was lifted by a Chapman derrick boat which was towed from the yard to the Waterside station, a distance of about two miles, and deposited the conduit section in the water within four hours.

The conduit was placed approximately over the required position in an enclosure formed by guide piles to which it was moored with a clearance of about 2 ft. It floated empty with a draft of about 27 in. The top plate of the outer shell was removed and the concrete buckets handled by the stationary derricks were dumped into the space between the shells and the concrete was thoroughly rammed under the bottom of the inner shell by men working in that narrow space. It required about three days to deposit the 120 yd. of concrete required to fill the space between the shells, and the additional weight increased the draft to 13½ ft.

The top plates were permanently screwed in position, thus completing the continuity of the outer shell, and preparations were concluded for sinking the conduit to position on the tops of the piles which had been cut off to heights approximately corresponding with the lower surface of the conduit. The spaces around the pile tops had been filled with concrete deposited through the water in bottom dumping buckets with their tops covered with canvas. The surface of the concrete was dressed to conform approximately with that of the conduit by divers using transverse templates set to reference nails previously driven at the required height on the faces of the guide piles.

At each end of the conduit 2½-in. steel eyes were riveted to several of the angle ribs on both sides of the outer shells and formed connections for sixteen 4-part ⅝-in. wire rope tackles suspended from transverse timbers passing over the conduit and supported by the longitudinal caps of the guide piles. When all was in readiness, water was pumped into the conduit through two 3-in. pipes in the tops of the bulkheads until the conduit was entirely submerged and an estimated load of about 1,000 lb. was put on the tackles. Pumping was then ceased and the conduit was lowered by allowing about 2 in. of the ⅝-in. line to overhaul through each of the tackles at one end, lowering it about ½ in. and then repeating the operation at the opposite end and so on until in about four hours the conduit was lowered to rest on the foundation without having permitted any possibility of sudden shifting of the water ballast, which might have caused the conduit to sink irregularly.

As the conduit was not seated in exactly the required position at first, a small quantity of water was pumped out of it; it quickly floated, water was pumped in, it was again landed, and again floated and landed a third time before the position was satisfactory. By this means a very accurate adjustment was secured, the alignment being within 2 in. horizontally and ¼ in. vertically.

After the conduit was adjusted in its final position, concrete bags were rammed under it by divers to form cradles about 8 ft. apart and the spaces between them were filled with cobblestones also rammed in position by divers. Finally the divers' work was completed by the removal of the wooden bulkheads, that for the shore end being taken through the conduit and removed from the outer end, because there was not sufficient clearance within the sheet pile cofferdam to permit the timber to be removed at the shore end. The steelwork of the intake and discharge conduits was built simultaneously, and after the intake tunnel was sunk in position as above described the discharge tunnel was sunk in the same manner. About one week was required for filling, sinking and adjusting each of the conduits. The work was executed by the Phoenix Construction Co.

The New York Municipal Office Building.

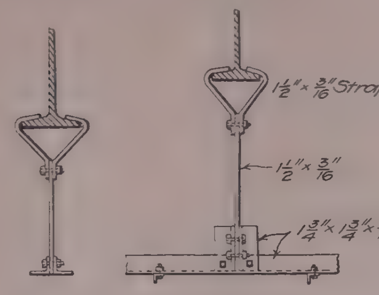
The great municipal office building projected by Mr. Gustave Lindenthal while bridge commissioner of New York City seems on a fair way toward construction. This project is one of the best of the numerous good things he suggested while in office. It provides an adequate terminal in Manhattan for the Brooklyn bridge and offices for numerous municipal departments now in rented quarters. Tenants on four of the blocks to be covered by the structure have been ordered to vacate the premises by the first of next month, and plans and specifications for the first contracts are now completed. The city pays enormous rentals for space in various office buildings and while some of this space is overcrowded other parts are not fully utilized, for it has been very difficult and sometimes impossible to lease quarters suited for the requirements of the departments. Estimates made independently a good many times have shown that the proposed office building will furnish better facilities at a lower net cost than the present arrangements, and will have the additional advantage of bringing the departments together under one roof within a few minutes' walk of the City Hall. The undertaking is a very large one, the cost of the ground alone being estimated at $5,000,000, but it seems the most logical means of utilizing to its fullest extent the land needed for the loops at the bridge terminal.

A Diesel Engine Plant has been installed at the Wayne Paper Mills at Hartford City, Ind., consisting of two 225-h.-p. engines direct connected to three-phase alternators. Records of operation are said to show that, on an average, 11 gal. of crude oil are consumed per 100-kilowatt-hours at a cost of 3.4 cents per gal., although the consumption has run below 10 gal. for considerable periods under favorable conditions.

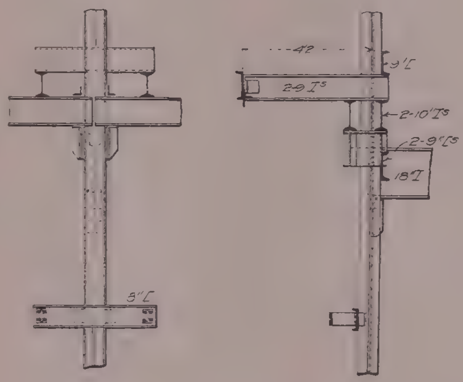
The Keyser Building, Baltimore.

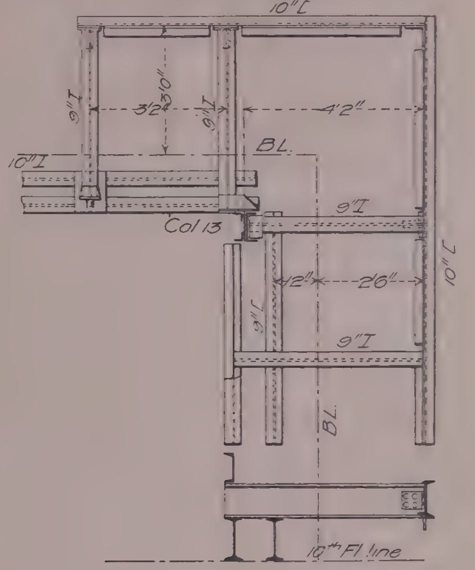
The Keyser Building, in Baltimore, is a ten-story, steel-cage structure, L-shaped in plan, with extreme dimensions of about 80 x 107 ft. The steelwork is remarkable for its uniformity and the simplicity of the standard connections and details adopted. It has thirty-seven columns spaced about 15 ft. apart in both directions in six longitudinal and eight transverse rows. In the typical floors the girders consist of single 15 and 18-in. I-beams on the center lines of the columns and the floorbeams are 9 and 10-in. I-beams from 5 to 6 ft. apart, which are supported directly on the girders and on the columns. The panels are uniform, except in the angle of the L, where a special arrangement is provided for the elevator and stairway shafts, without involving a change from the general rectangular layout. The walls are carried at each story by pairs of I-beams 9 in. deep for the light court wall and 12 or 15 in. deep for the other walls, except where special construction is required for the architectural features.

As the roof-beams are slightly inclined to afford drainage, the horizontal ceiling of the tenth story, immediately below it, is not built directly on the beams as in lower stories, but is suspended from them at a minimum distance of about 12 in. clear. The plaster ceiling is built on expanded metal lath, attached to a light horizontal angle-iron framework suspended from the roof-beams and girders. Pairs of bent 1½x3/16-in. straps engage the bottom flanges of the I-beams and have their lower ends bent vertical and bolted together with the 1½x3/16-in. vertical strap between them. The latter is either bolted to the vertical flanges of 1¾x1¾x3/16-in. angles 4 ft. apart, or, when its plane is at right angles to these angles is provided with short vertical angle clips which, through their opposite flanges, are bolted to the ceiling angle. Transverse 1x1x⅛-in. angles 16 in. apart are bolted to the horizontal lower flanges of the main ceiling angles to receive the expanded metal. The roof framing corresponds with that of the floors, except that the beams and girders are slightly inclined and that their weights are reduced on account of the absence of live load, the dimensions remaining practically the same.

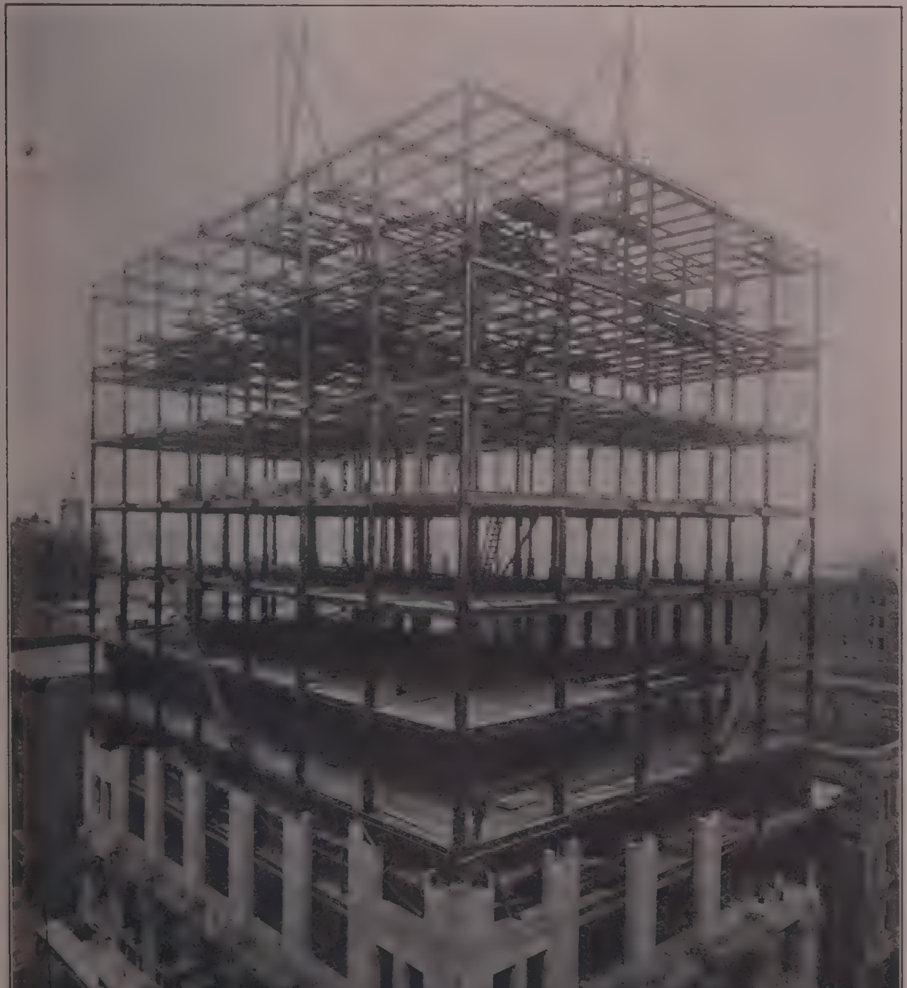


Suspended Ceiling.

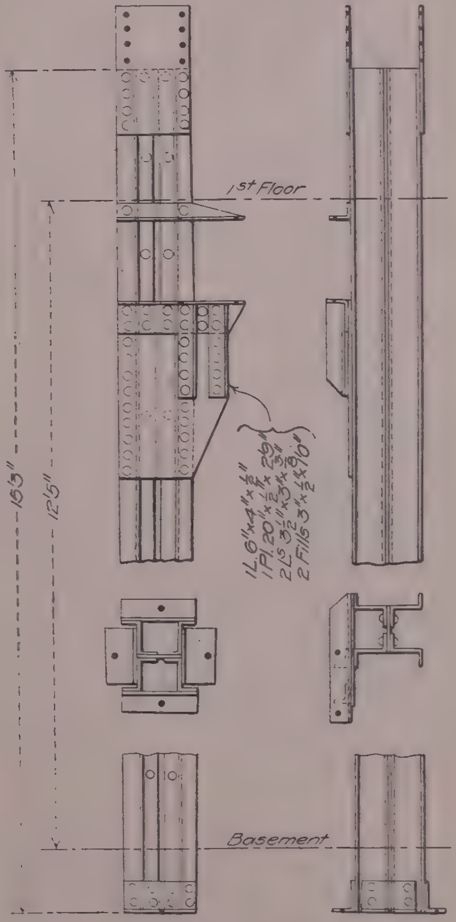




Construction of Cornice Framing at Corner.



Keyser Building in Course of Construction.



Typical Column.

A heavy cornice is built on the two street sides of the building and has a steel framework projecting about 4½ ft. beyond the centers of the wall columns. The principal members of this framework are pairs of 9-in., 21-lb. cantilever I-beams about 5 ft. long, united at their outer ends to a continuous facia girder made of a single 10-in., 15-lb. channel and a 3x3-in. angle. The cantilever girders are arranged 23 ft. 2 in. apart on opposite sides of the columns, and are seated on a pair of 10-in. I-beam wall girders supported on column brackets. The outer line of the wall girders is just clear of the face of the column and serves as a fulcrum for the cantilever. The inner line is nearer the column centers and the beams are cut to clear the column flanges. The upward reaction at the inner end of each pair of cantilevers is taken by a 9-in., 13¼-lb. channel 3½ ft. long, which is riveted across the inner face of the column and projects equally on both sides, thus really forming a double balanced cantilever. At the corner of the building the arrangement of cantilevers is modified as shown in the part plan. The 9-in. reaction channel being extended across the adjacent panels to the next columns and serving to secure the cantilevers.

All columns have H-shaped cross-sections made with four Z-bars and a solid web plate, a construction favorable for symmetrical beam and girder connections. When the latter are at right angles to the webs, they are made of top and bottom reinforced shelf angles riveted across the flanges. When parallel with the webs, they are made of vertical web connection angles the field rivets in which are easily driven on account of the absence of lattice and tie bars connecting the column flanges. The wall girders are carried beyond the exterior faces of the columns by shelf angles with reinforced horizontal flanges riveted to the tie plates, which project beyond the faces of the columns.

The building contains about 850 tons of structural steelwork which was erected by two stiff-leg derricks operated by hoisting engines in the lower part of the building. As the erection progressed, each derrick lifted the other to the second tier of beams above and was in turn lifted by it, thus providing for rapid changes with comparatively short interruption to the work of erection.

The wall masonry was handled by single boom derricks seated on brackets in the middles of the street fronts. The booms were rigged with topping lifts attached to the columns of the building, so as to avoid the necessity of separate masts, and were moved up from story to story as the work advanced, thus obviating the necessity of long overhauls for the lower story and permitting the masonry to be commenced before the steel erection was finished.

Messrs. Wyatt & Nolting were the architects of the building, and the American Bridge Co., was the contractor for the steelwork, which was fabricated at its Pencoyd plant and was erected under the direction of Mr. H. F. Lofland, division erecting manager.

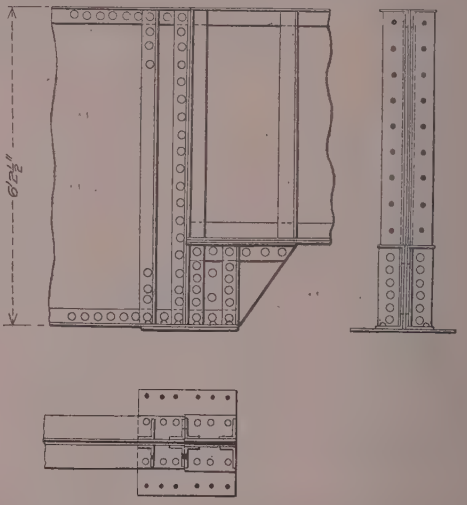
The Use of 500-Volt Railway Generators for the supply of current upon 250-volt direct-current lighting mains has been successfully accomplished by the Topeka (Kansas) Edison Co. Three railway generators which were available at times of heavy lighting load were made serviceable upon the lighting system by arrangement of connections permitting the compounding coils to be cut out and the field rheostats adjusted for about half excitation, and reducing the operating speed of the machine about 5 r. p. m. by adding weights to the engine governor. The generators carry the load at the lower voltages without sparking or heating and without difficulty of regulation, the result being that the change from one service to another is accomplished with little difficulty.

The George's Creek Viaduct, Southern Ry.

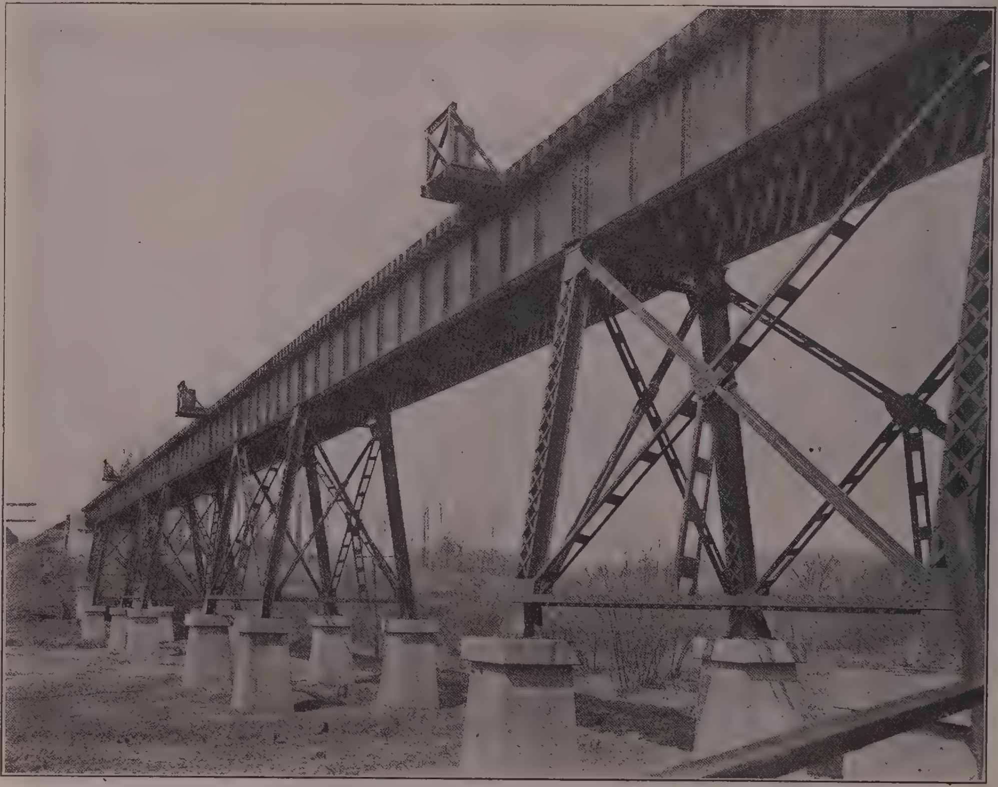
The George's Creek viaduct of the Southern Railway, near Greenville, S. C., is a single-track plate girder structure about 398 ft. long and 40 ft. high. It has four 30-ft. towers seated on pyramidal concrete piers and connected by 60-ft. spans. Each tower is made with two vertical bents each having two columns 10 ft. apart on centers at the top and battered 1:6. They have rectangular cross sections made with two 15-in. channels latticed on both sides. Longitudinal bracing is field riveted to jaw plates shop riveted across the channel flanges and the transverse bracing is field riveted to jaw plates shop riveted to the channel webs. The bottom tie plates project beyond the channel flanges to stiffen the 30 x 36-in. extended base plates which are anchored to the concrete piers with pairs of short 1½-in. wedge bolts. All struts are made with pairs of angles with their horizontal flanges connected by tie plates and lattice bars; 3 x 3½ x 8-in. angles are used throughout for the diagonals and 6 x 4 x ⅜-in. angles for the transverse horizontal struts and five 1½ x ⅜-in. angles suspended at the center from the intersection of the diagonals are used for the longitudinal struts. Sheets of lead ⅛-in. thick are interposed between the tops of the piers and the seat of the columns.

All girders have a uniform depth of 74½ in. from back to back of flange angles and are braced together with vertical sway frames of the usual pattern spaced about 12 ft. apart, and have zigzag top lateral angles. The tower girders are made with 74 x ⅜-in. web plates 30 ft. long and with two 6 x 4 x ⅜-in. angles without cover plates in each flange. The ends of the girders abut on the center lines of the tower bents with those of the 60-ft. spans and are connected to them by double web cover splice plates having one vertical row of field rivets on each side at fixed bearings. At expansion bearings the splice plates are field riveted to the 30-ft girders and have bolts engaging slotted holes at the ends of the 60-ft. girders.

At one end of the viaduct, the 38-ft. span is temporarily omitted, but provision is made for future girders 4 ft. 6½ in. deep which will be supported on brackets shop riveted to the ends of the 30-ft. girders and field riveted to the tops of the tower columns as indicated by the accompanying detail drawing. The 60-ft. girder webs are each made with two 74 x 7/16-in. plates about 20 ft. long shop spliced near the center with four vertical rows of rivets through two 14 x ⅜-in. cover plates. The flanges are made with pairs of full length 6 x 6 x ¾-in. angles and three 14-in. cover plates from 28 to 48 ft. long and ½ in. and 7/16 in. thick. All girders have lower flange bearings on the column caps to which they are riveted at fixed points. At expansion points they are secured by bolts through holes slotted in the flanges and guide strips are riveted to the column caps on each side of the flange angles with cover plates engaging the upper surfaces of the flanges.



Seat of Short Girder Span.



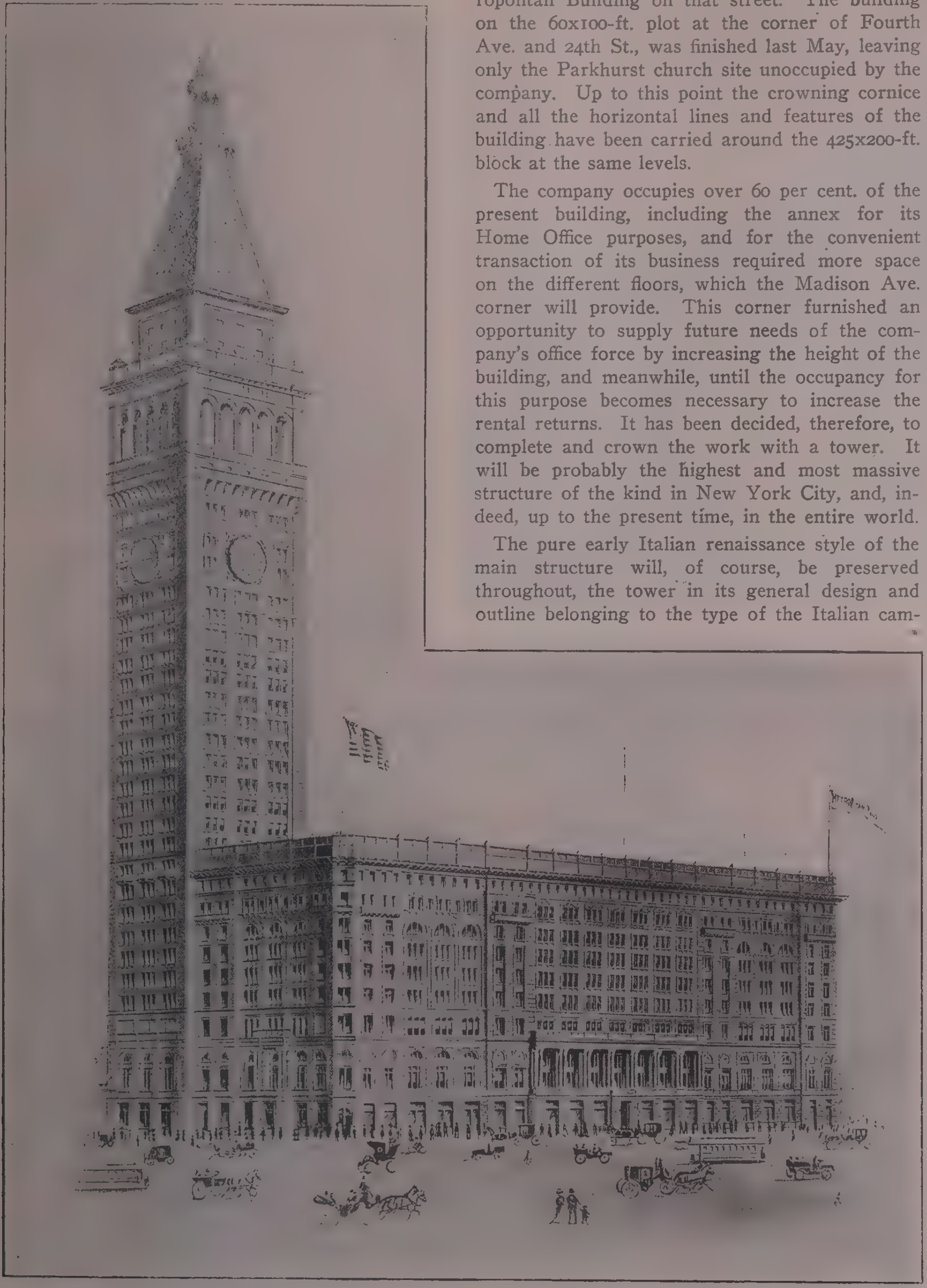
General View of Completed George's Creek Viaduct.

The viaduct was designed in accordance with the requirements of the Southern Railway, Mr. D. W. Lum, chief engineer of structures. The American Bridge Co. was the contractor for the fabrication and erection.

The Rules and Specifications for grading lumber adopted by various manufacturers' associations have been compiled and published by the Forest Service.

The Tower of the Metropolitan Life Building, New York.

The Home Office Building of the Metropolitan Life Insurance Co., occupying the block bounded by Madison and Fourth Aves., 23rd and 24th Sts., New York, is about to be completed by a great tower, which will be erected on the northwest angle of the block where the Gothic tower and steeple of the Madison Square Presbyterian Church lately stood.



The Metropolitan Life Building with its Proposed Tower.

The building operations of the company on the block commenced in May, 1890, when the fine old brownstone mansions at the corner of Madison Ave. and 23rd St. were demolished and excavations were started. By the spring of 1893, the building was sufficiently advanced for the company to move in, and by the summer of 1894 this first section of the building, with a frontage of 125 ft. on Madison Ave. and 145 ft. on 23rd St. was completed. The rapid and constant increasing business of the company required in 1895 an addition on 24th St., 115 x 100 ft. in area, and in 1898, a two-story extension with a frontage of 180 ft., occupying the center of the 23rd St. half of the block.

The next operation, started in 1901, was an important one, and extended the building for its full height to and around the corner of Fourth Ave. and 23rd St., and included the sites of the old Academy of Design and of the Lyceum Theatre, as also some three-story brick structures on 24th St. adjoining the first extension of the Metropolitan Building on that street. The building on the 60x100-ft. plot at the corner of Fourth Ave. and 24th St., was finished last May, leaving only the Parkhurst church site unoccupied by the company. Up to this point the crowning cornice and all the horizontal lines and features of the building have been carried around the 425x200-ft. block at the same levels.

The company occupies over 60 per cent. of the present building, including the annex for its Home Office purposes, and for the convenient transaction of its business required more space on the different floors, which the Madison Ave. corner will provide. This corner furnished an opportunity to supply future needs of the company's office force by increasing the height of the building, and meanwhile, until the occupancy for this purpose becomes necessary to increase the rental returns. It has been decided, therefore, to complete and crown the work with a tower. It will be probably the highest and most massive structure of the kind in New York City, and, indeed, up to the present time, in the entire world.

The pure early Italian renaissance style of the main structure will, of course, be preserved throughout, the tower in its general design and outline belonging to the type of the Italian campanile of the period. It will rise from a rich base, continuing in line and detail the general features of the four lower stories of the main building. Above the fourth story, the design of the shaft of the tower will be severely simple, consisting of three groups of triple windows on each side, with heavily moulded and deeply recessed jambs; this treatment to extend through 21 stories without interruption other than a course of projecting marble balconies at the level of the main cornice of the main building, whose projection will have the effect of continuing the line of strong shadow of that cornice without interfering with the upward trend of the piers and heavily rusticated angles of the tower. At the twenty-first, twenty-second and twenty-third stories, or 324 ft. above the sidewalk, will be a great clock with dials on each front 25 ft. in diameter, hands 12 ft. and figures 4 ft. long.

The capping to this shaft will consist of, first, a line of boldly projecting double bracketted and panelled balconies, and then deeply encased Ionic loggias, with five arched openings on each side of the tower. Over the arched openings will come a deep frieze with windows and then a cornice and parapet balcony. Over the parapet the walls of the tower will be offset, receding 8 ft. on each face. This offset portion will continue up four stories and form a base for a pyramidal termination with an octagonal collonated observatory, 658 ft. above the sidewalk level.

Six express elevators will be installed in the tower, four of which will terminate at the fortieth story, and the other two at the forty-second story. The twelve lower stories will be served from the elevators in the adjoining section now built, the present elevator corridor giving direct access to the tower. No woodwork will be used in the construction and finish of the tower unless the same be protected with a metal cladding. The floor finish throughout will be of cement or terrazzo. All power, heat and light will be supplied from the plant now installed in the building.

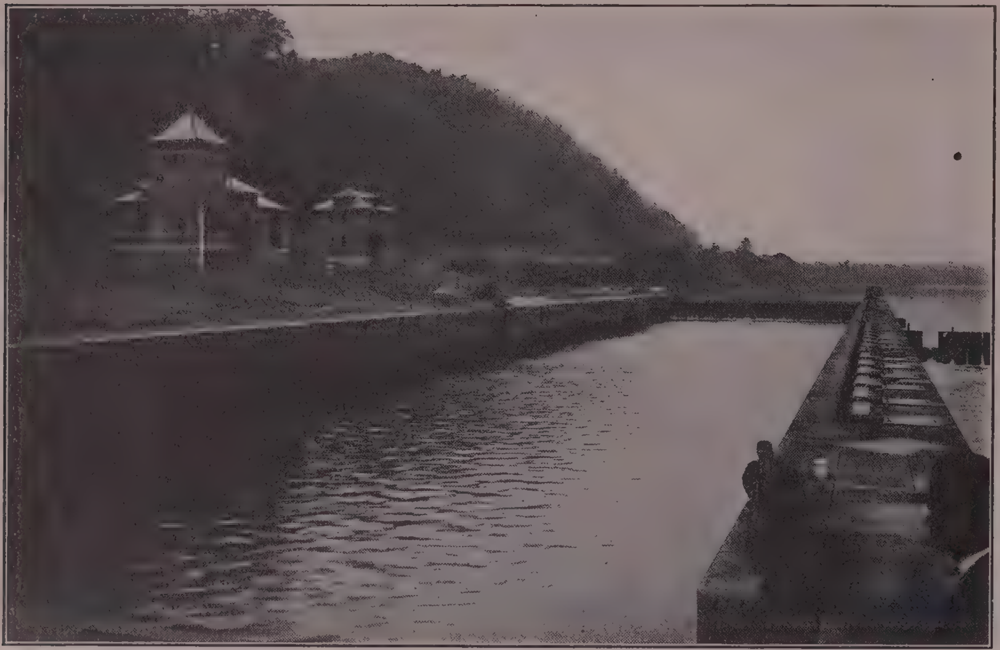
The general dimensions of the tower are as follows: Frontage on Madison Ave., 75 ft.; frontage on 24th St., 85 ft.; height above sidewalk, 658 ft.; height from cellar floor to top, 680 ft.; total height from foundation, 690½ ft.; height of clock face above sidewalk, 346 ft.; height of loggia floor above sidewalk, 392½ ft.; top of loggia balustrade and offset level above sidewalk, 453 ft.; floor of lookout (forty-sixth story) above sidewalk, 603 ft.; center of window over lookout (highest point for observation) above sidewalk, 633 ft.; number of stories above sidewalk in tower, 46; number of stories below sidewalk in tower, 2; grand total of cubic feet in Metropolitan Building, 16,237,034; grand total floor area in Metropolitan Building, about 25 acres, 1,085,663 sq. ft.

The steel framework of the new portion of the building, including the tower, has a total weight of about 8,100 tons, and is supported on I-beam grillages with concrete footings on the solid rock. The tower has lateral dimensions of 75 x 85 ft. at the bottom and is built with an entasis tapering the long and short sides 12 and 8 in. respectively between the fifth and thirtieth floors. The columns in the exterior facade remain vertical but have their shafts correspondingly tapered. The exterior walls are entirely of white marble and the floor is of concrete flat arch construction. In the framework there are twelve wall columns and eight interior columns. All of them being connected at every fourth floor by a system of flat steel diagonal bars riveted to the top flanges of the floorbeams and forming a system of triangular trusses to resist transverse distortion. The wind pressure assumed is 30 lb. per square foot, over the entire exposed surface of the tower, and is also resisted by the deep wall girders and solid web knee-braces reaching to the centers of the panels at the corner columns. The corner columns are calculated for maximum stresses of 7,500,000 lb. and have a cross-sectional area of 540 sq. in. made up with twelve 8x8x1-in. angles and heavy web and cover plates which together with connections make a weight of about one ton per linear foot. The building throughout has been designed by Messrs. N. Le Brun & Sons, with Messrs. Purdy & Henderson as consulting structural engineers.

THE ENGINEERING SOCIETY of the Carolinas, Inc., has established its headquarters at Charlotte, N. C. Engineers of every branch are eligible.

Progress of the Canalization of the Ohio River.

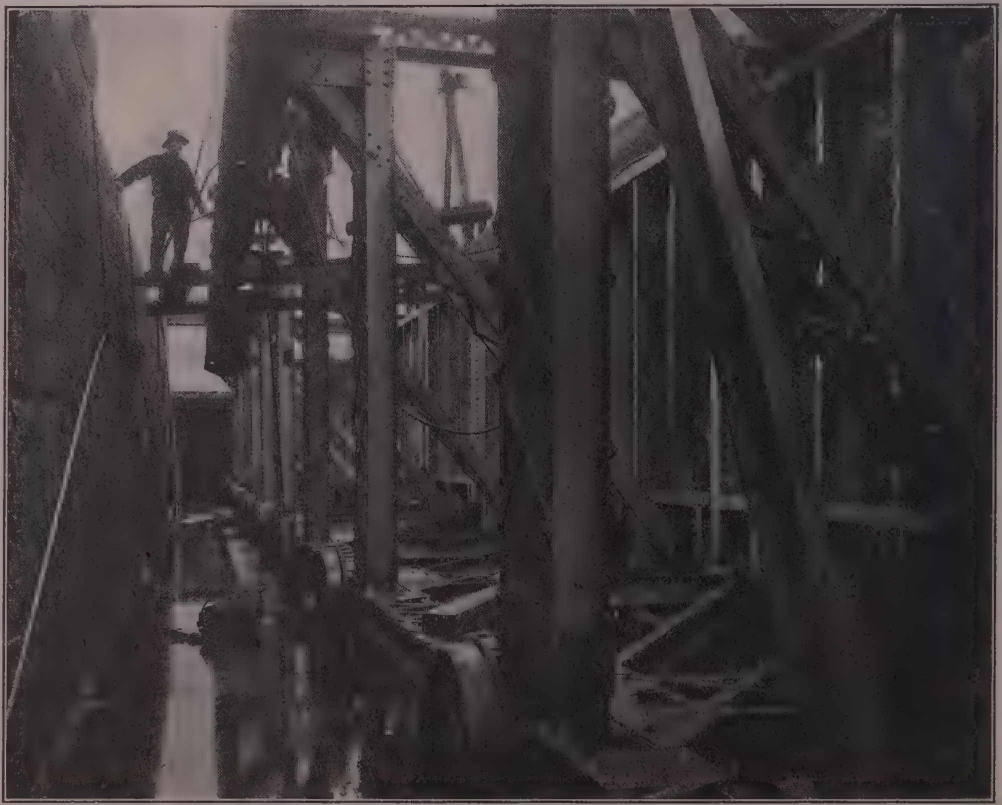
The work of the Corps of Engineers, U. S. A., on the Ohio River between Pittsburg and Beaver, Pa., has reached a stage where it can be said with reasonable accuracy that all of the six dams between the two cities, built in connection with the canalization of the Ohio River, will be completed before the end of next summer. When they are finished the Ohio will have a depth of 9 ft. for 30 miles below Pittsburg and about 50 per cent. will be added to the time during each year when there is a boating stage of water out of Pittsburg.



The Beaver Lock, Typical of Ohio River Canalization near Pittsburg

When Congress appropriated the money for this improvement two years ago the expedient was adopted by the river and harbor committee of calling all the territory embraced "Pittsburg harbor" to avoid committing itself to the scheme of the canalization of the Ohio at a 9-ft. depth clear through to Cairo. However, through efforts of the Ohio River Improvement Association and other friends of river navigation, the river has been canalized to a 6-ft. depth its entire length and a vast amount of the most telling work done at the shallowest part of the river. The remainder of the river has been surveyed for the 9-ft. improvement and it is hoped that ultimately an all-the-year stage of 9 ft. from Pittsburg to Cairo may be developed, as this would ensure open navigation from Pittsburg to New Orleans twelve months in the year.

Dam No. 1 at Davis Island, No. 2 at Glenfield, and No. 6 at Beaver have been completed. No. 3 at Osborne and No. 5 at Rochester are practically finished, and No. 4 at Legionville will be finished sometime next spring, if no unexpected delays occur. The dam at Beaver was fully described in The Engineering Record of March 11, 1905. The locks operated in connection with these dams are each 600 x 110 ft., in the clear, these dimensions being necessary on account of the principal traffic to be handled, coal in flat-bottom barges of great length and width, moving in fleets. The lock gates are of the rolling type and run into slips behind the land wall of the lock. They are steel trusses mounted on flanged wheels. A general idea of the gates and of the entire lock may be had from the accompanying illustrations. The work has been in the charge of Major Wm. L. Sibert, Corps of Engineers, U. S. A., of late.



Trusses for Lock Gates, Ohio River Canalization.

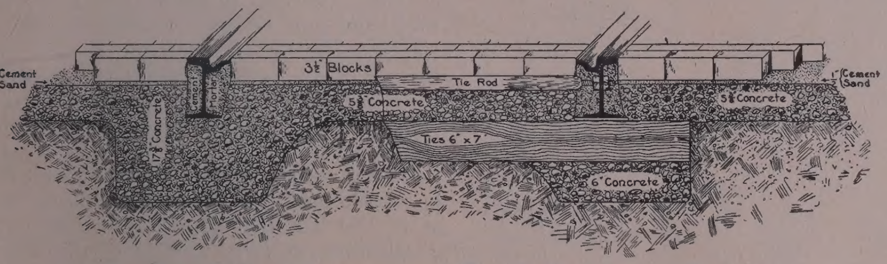
The Development of Treated Wood Block Pavements in the United States.

Treated wood block pavements have, in the past few years, gained popularity in many cities of this country in spite of the bad reputation given to wood as a paving material by round cedar blocks and Nicholson block pavement, both used extensively and unsuccessfully fifteen or twenty years ago. An account of the development of wood pavements in this country, was recently presented by Mr. F. A. Kummer, before the Boston Society of Civil Engineers and published in the "Journal" of the Association of Engineering Societies. According to this paper, the four important elements which enter into the construction of a first-class treated rectilinear wood block pavement are: The foundation; the character of the wood employed; the character and amount of treatment; the method of laying the block.

In this country, about the time that creosoted wood block began to be seriously considered, great quantities of long-leaf pine began to come into the Eastern market, and this wood, owing both to its plentiful supply and its toughness and hardness and adaptability for the reception of creosote oil, seemed ideal for paving blocks. It was determined that the blocks must be made of the heart of the tree only, as the sap wood, being much softer than the heart, would tend to wear away more rapidly and produce uneven wear on the surface of the pavement. At that time all-heart long-leaf yellow pine was readily obtainable in large quantities at prices about $10 per 1,000 less than would now have to be paid for similar lumber containing quite a high percentage of sap. The all-heart lumber, owing to the great demand for it, is out of the market except at prohibitive prices. Tests are now being conducted on a variety of other woods. Among them the black gum of the South seems to promise the best results. It exists in large quantities in the South and as it is not very useful for general lumber the chances of securing it in large quantities, at reasonable prices, for a considerable period are good. It is tough and hard, has an irregular grain, and resists decay and wears well when properly treated, though when untreated, being a swamp wood, it decays rapidly.

Many of the streets laid some years ago, treated with 8 or 10 lb. of straight creosote oil per cubic foot, absorbed water, swelled up, buckled and often got into a dangerous condition. In discussing the remedy for this difficulty Mr. Kummer said: "It was determined that the block must be as completely filled with preservative material as it would permit; that is, all the pores of each block should be thoroughly filled with oil. It was also felt that ordinary straight creosote oil, the dead oil of coal tar of commerce, was not sufficiently waterproof to properly exclude moisture from the block; and to overcome this difficulty melted rosin was introduced along with the oil, the two materials making a perfect mixture, which not only impregnated all parts of the block, but sealed up the pores so that moisture was excluded and the fiber of the wood stiffened and rendered better able to resist impact and abrasions. The proportion of rosin used at first was from 50 to 60 per cent., but the general practice at the present time is to use about 25 per cent., the reduction in the amount of rosin being made possible by improving the quality of the oil used. Some of the lighter creosote oils are of such a low specific gravity that they require 50 per cent. of rosin to render them sufficiently dense to thoroughly seal up the pores of the wood and prevent the entrance of water; but by specifying oils of very high boiling points, very heavy and dense and non-volatile oils may be secured which do not require such a high percentage of rosin. This change does not in any way impair the value of the treatment, and at the same time prevents the cost of the block from running to a prohibitive figure, owing to the fact that rosin has advanced several hundred per cent. in value during the past few years, and at its present value, if 50 per cent. of it were used, the cost of the pavement would be needlessly increased."

The practice abroad has been to lay the blocks, both treated and untreated, with a space of ¼ to ½ in. between them filled with tar and gravel. The wide joint was intended to furnish a better foothold and to allow room for expansion. In Mr. Kummer's opinion the wide joint fails to fulfill its second purpose because it allows moisture to reach the blocks readily and becoming packed tight with gravel, tar and dirt it has no elasticity. With tight joints the water, instead of getting under the blocks runs off to the gutters. In the best practice now the blocks are driven up tightly against each other.



Track and Wood Pavement on Washington Street, Boston.

The first wood pavements in the East were laid on a sand cushion, but it is better to use a rigid base without any cushion, Mr. Kummer said. The surface of a wood pavement must be kept uniform and the English method of accomplishing this is to float the surface of the concrete with mortar, which is allowed to become hard and smooth before the blocks are laid. Sometimes it is covered with a layer of hot pitch in which the blocks are set. The usual method here is to true up the surface of the concrete in the same way with a mortar bed, but it is mixed damp instead of wet, and the blocks are laid in it before it has set and then tamped with an asphalt rammer until the surface is smooth and even. A certain amount of the mortar is squeezed up between the joints at the bottom of the block so that water cannot work its way under the block.

The dimensions of the blocks used have varied considerably. The rapidity of wear, convenience of laying and width of available lumber all acting at times as determining factors. The size recommended by Mr. Kummer is about 3 in. wide, 8 in. long and 3½ or 4 in. deep.

For filling the joints clean, fine sand is favored, used very dry and thoroughly swept into the joints. Unless a very fine, clean and dry sand is used a cement grout joint will give better results. The sand is suitable on streets where there is heavy traffic which will expand the head of the blocks and practically close the joints.

On streets of light travel some form of pitch joint is preferable. The company with which the author is connected has paved some streets in Baltimore, Md., where the surface was swept with hot pitch and sprinkled with fine granite screenings, the idea being that these will be crushed into the joints and surface and tend to reduce slipperiness. In both American and English practice the blocks are usually laid with their length at right angles with the curb.

In conclusion Mr. Kummer expressed the opinion that the perfect wood pavement would be laid on a well-drained and compacted foundation, upon which is placed a suitable concrete base with its upper surface brought to perfect crown and grade by the use of cement mortar in which the blocks are set while it is damp or upon which a coating of hot pitch is spread in which to set the blocks. The blocks should be of a dense, tough and homogeneous wood, the pores of which are entirely filled with an antiseptic and waterproof mixture to exclude water. They should be driven as tightly together as possible, and the joints filled with clean fine sand, cement grout or pitch, all the blocks being of a uniform depth so that the surface of the street is even. Such a pavement, if not cut to pieces by public service corporations should have, under the heaviest travel, a life of from ten to fifteen years, with a rapidly increasing life as the severity of the traffic decreases.

In a discussion of the paper Mr. Arthur L. Plimpton called attention to the wood block pavement recently laid on Washington St., Boston, where an unusual type of street-car track was used. The rails are supported on the usual tie construction, the ties being 2.5 ft. on centers, and supported in and on a continuous concrete beam extending 6 in. below the bottom of the ties, and about 5.5 in. above them, giving a total thickness of about 17.5 in., as shown in the accompanying illustration. These beams are connected by an arch of concrete, which gives about 5.5 in. of concrete base in the middle for the wooden block pavement. In order to prevent water from working down at the side of the rail, which, when followed by freezing weather, will cause the blocks to heave up, it was decided to plaster with cement mortar next the rail its entire height just before putting in the concrete, which insured intimate contact between the concrete and the rail and left no voids in which water could accumulate. In relaying the tracks on Beacon St. the wooden blocks themselves were laid on a layer of cement mortar and the joints filled with cement grout. Cars were not run on the tracks on either street until the concrete had been in place for ten days.

The object of this form of track construction is to eliminate movement of the rail under passing cars as far as possible. In some recent work in connection with brick pavement a form of screw has been used instead of the usual track spike which, with its vastly greater holding power, will certainly help a great deal to prevent movement of the rails. If the results justify the added cost, it will probably be adopted instead of the spike in future work in connection with expansive forms of pavement.

The Design of Saw-Tooth Roofs.

During the discussion on saw-tooth roofs at the recent meeting of the American Society of Mechanical Engineers, Mr. Samuel M. Green, of Holyoke, Mass., pointed out that practically all the troubles of the saw-tooth skylight are caused by the severe winter weather conditions of a northern climate. They are classed under two heads; leaks caused by outside conditions, and inside condensation, due to low outside temperatures. Rain will find any ordinary crevice, and ice and snow will cause water to back up and find imperfections that otherwise would not cause trouble. Snow and ice will also freeze to the roof, and cause the roofing material to sag, while frost getting under the nail heads will pull them out. In textile work a high degree of humidity is maintained in the weave sheds, with the result that, in cold weather, condensation on the glass is very great. This is objectionable because a drop of water on a sized warp causes bad work.

In a northern climate the English type of roof with sharp gutters is not practicable, and several companies which first used such a gutter have changed to the flat one, made of regular roofing material. A gutter pitch of ½ in. per foot is none too much, in Mr. Green's opinion, but usually is all that can be reasonably obtained. It is a mistake to try to carry all the water to the end of the gutter, he stated, and an ample number of downtakes should be provided, along the length of the gutter, carrying them down inside the building. Double glazing, on account of its greater non-conductivity of heat, is preferable to single, though more difficult to repair. The condensation water should be removed by means of inside gutters. The roof should be strong enough so that it will not have to be cleared of any but heavy snows and the material should be such that it can be walked on if necessary without damage.

The best lighting results are obtained by the use of factory ribbed glass, according to Mr. Green, which diffuses the light, giving all parts of the room illumination of equal strength. All cross beams that cast shadows should be avoided, in buildings for textile purposes, by the use of a sufficient number of posts. Rods rather than beams for the lower members of the roof trusses are a good idea, though these beams do not interfere with the light as much as those running parallel with the gutters.

Illustrating the manner in which, in his opinion, saw-tooth roofs can be most satisfactorily constructed, Mr. Green described a 900-loom weave shed, designed by himself. The building is of semi-steel construction. The posts are steel I-beams, anchored to concrete piers and extending in one piece from piers to roof. The wood floorbeams are bolted to I-beam stringers, which are riveted to the posts. The 4-in. floor planks are spiked to the floorbeams and, at the wall ends, are attached to the brick wall by a steel angle and bolts. The roof and the posts are tied together by light steel channels and angles, which form the shafting supports.

An accompanying illustration shows the details of gutter, glass and ridge construction. The pitch of the gutter is made by light cross pieces on top of the roof timbers. The curb is of 4-in. pine, the top of which is beveled at a sharp angle, to permit the water of condensation to readily run off the curb, and it is also grooved to form a drip edge for the water to drip into a small copper gutter, which is connected by means of a lead pipe to the regular roof downtake. The gutter proper is made as follows: The corners formed between the bottom of the gutter and the curb on one side, and the gutter and the flat roof on the other, are filled with a fillet of wood of curved shape. Then sheet asbestos, 1/16 in. thick, is laid, extending up to within 3 in. of the glass on one side, and 2 ft. on the flat roof on the other side. Over this asbestos is nailed galvanized iron of about No. 24 gage, extending to the same heights. This makes the gutter firm to walk upon and covers up any imperfections in the plank, or cracks between them. The asbestos prevents moisture from the room reaching the galvanized iron, condensing, and dripping back into the room.

After the gutter is so prepared it is ready to receive the regular five-ply asphalt or pitch roofing. It is well to lay an extra ply in the gutter, to increase the strength. The roofing should be thoroughly nailed and mopped. On the glass side, it should be brought up to within about 2 in. of the glass. To protect this edge, a flashing of galvanized iron was used, the edge of which was bent and sharpened and then driven into a cut in the curbing made by a special tool, shaped like a calking tool. Then it was nailed, with 1 in. spacing of nails, at the top and bottom. Slag, on account of its lightness, porosity, and better holding qualities, was used to cover the gutter and flat portion of the roof. The curbing under the glass was thoroughly mopped, up to the glass.

The stiles or bars were made of white pine, firmly fastened to curb and ridge with brass screws, and shellaced inside and out before being painted with pure white lead and oil. The glazing was double, the inside light being ¼-in. factory ribbed and the outside being plain double-thick glass. The outside glass was held from slipping downward by means of brass screws, and both lights were thoroughly puttied with 33 per cent. white lead putty.

Roof down-takes were spaced about 60 ft. apart to enable the gutters to empty themselves quickly. These are 4-in. copper pipes, carried down to the basement floor within the building posts, the posts for the down-take pipes being of a "built-up" channel section, whereas the regular posts are I-beams. To prevent condensation, the copper roof bowl was covered with plastic magnesia and the down-take pipes were wrapped with asbestos. This piping was protected from likelihood of damage by means of a galvanized iron shield.

A weave room should be thoroughly ventilated, first, to give healthful conditions, and second, to give even humidity throughout the room. In this room ventilation was accomplished by means of two motor-driven steel plate blowers, located in the basement. Their combined capacity is equal to a ten-minute air change. Air can be drawn either from out of doors or from the basement, and cooled by contact with artesian well water. It is discharged into the room in fifteen places, at a height of about 8 ft. above the floor, and leaves by means of innumerable openings near the floor line, into the basement, by four revolving ventilators in each saw tooth and by the windows.

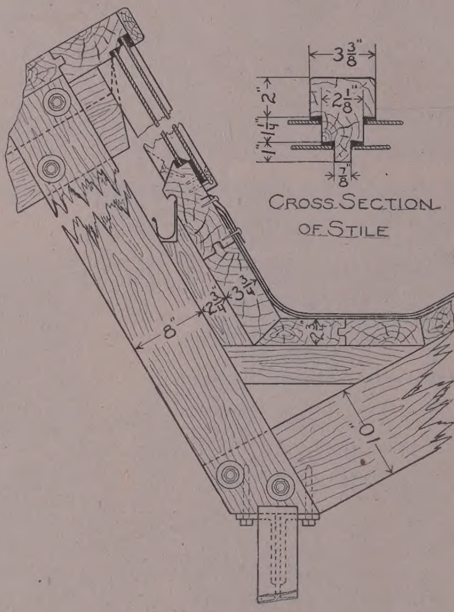
Roof ventilators have been a source of great annoyance on account of the condensation that occurs inside them and the difficulty of making them tight at the roof line. To prevent the former, both the stationary parts of the revolving elbow were double walled, making 1-in. air spaces. To care for the latter, the roof joint was made tight with a copper flashing, the flat portion of which was large in area and was placed before the roofing was laid. The upper edge of the circular portion of the flashing was hammered over and soldered to the top edge of the stationary part of the cowl. To close the ventilators, a damper of special design was used. The building is heated by direct radiation, two-thirds of the pipe being on the wall near the floor, and the balance at the ceiling. So far the entire design of the building has proved almost faultless.

Summarizing, Mr. Green indicates the main features of his design as follows:

1. Careful gutter design and construction to prevent leaks.
2. No metallic connection between inside and outside air; therefore no uncontrolled condensation.
3. Careful provision to remove the water of condensation on the glass.
4. No uncontrolled openings between the inside and outside, which let in cold air.
5. Minimum obstruction of light.
6. The use of factory ribbed glass, which diffuses the light so that what slight obstruction there is becomes unnoticeable.

A Fireproof Ferryboat.

A fireproof ferryboat just completed for the Pennsylvania R. R. ferry between Philadelphia and Camden is noteworthy for the use above the main decks of steel plates and structural shapes in place of wooden stanchions, carlines and sheathing. The outside framing consists of double channel window posts with horizontal angle bracing, and the inboard cabin bulkhead is made of heavy angle and I-beam posts to which is riveted 8-lb. plate sheathing. Each window post consists of two 4-in. channels with 5-lb. plate covers, to which the window frames are fastened directly. The ornamental interior finish of the cabins consists of panels of asbestos building lumber, which are screwed to small wooden blocks bolted to the inboard bulkhead posts, and finished with drawn-steel mouldings. The seats in the cabin are made of drawn-steel mouldings supported on steel angle-bars. The window sash, window sills and frames are of wood completely covered with sheet copper of No. 18 gauge. The pieces of wood forming these parts are first moulded in the section desired, then loosely wrapped with copper, and both together are drawn through dies that press the copper firmly down on the wood and lap-joint the edges of the copper sheet.



Cross Section of Gutter used with Saw-Tooth Roofs.

Concrete Box Sewers are being used quite extensively in Philadelphia where old sewers have to be replaced by others of larger capacity on substantially the same grades and lines. The walls are vertical, the bottom is troughed on the inside and paved with vitrified brick, and the top is a slab of concrete reinforced near its lower surface.

Indoor and Outdoor Railway Lighting by Gas.

The lighting of railway premises, both indoor and outdoor, has been made a specialty by Mr. Henry Fowler, of Derby, Eng., for many years, and in a paper on the subject presented on Dec. 14 to the Institution of Mechanical Engineers he summarizes the opinions he has formed regarding it. In the first part he describes the methods of measuring the intensity of illumination, and explains the types and characteristics of oil, gas, incandescent gas, incandescent electric and arc lights that have been used in railway service. This portion of the paper is hardly of general use to American readers, but the section describing the methods of illumination found useful for different classes of service on British lines is so interesting that it is reprinted here practically in full.

Freight Yards and Sidings.—In lighting these places, as distinct from goods sheds, two conditions may obtain; it may be that it is necessary to provide for lighting a space, as, for instance, the entrance of a yard, or a particular point, such as a capstan. Upon these considerations the type of light used will depend. In the first case high-powered lights are required, and they should be placed high up so as to distribute the light; in the second case a smaller light at the point required is all that is necessary. For the lighting of the yards themselves three-light incandescent gas-lamps, about 80 to 100 ft. apart, or arc-lamps about 100 to 120 ft. apart, give a good effect, and quite sufficient illumination under ordinary conditions. It frequently happens, however, that the necessity for providing light at some particular point, such as a crane, capstan, crossing, etc., causes the lamps to be placed much closer together. In small yards where neither electricity nor gas is available, Veritas oil-lamps in suitable cases may be used. It will be understood that the conditions vary so much that illumination curves of lighting of this description are not of much value, but from a number of readings which the author has taken, he thinks that if the light provided does not sink below 0.05 ft. candles at the ground level it will meet any case. In the lighting of sidings, the chief position to be considered is that of the switches. Here it is necessary not only to light the switches themselves, and the position of the "dummy" for changing them, where provided, but also to show when a car is standing clear where the roads diverge, so that shunting may take place safely by it. The lighting here required is therefore a combination of horizontal and vertical illumination, and if a single pair of switches has to be dealt with, a light of not too high power (say 100 candles), placed at not too great a height, is all that is required. Where several sidings run one after another into a shunting road and a line of lights is provided, 3-light incandescent gas-lamps, 100 ft. apart, or arc-lamps on higher posts and spaced a greater distance, will be found satisfactory. In some cases special lighting has to be provided, and as a case in point the author would quote gravitation sidings such as now exist on most railways. Here the number of the road the wagon is to go on is chalked on the end of the wagon before it is "cut" from the train and started down the incline. It is necessary that this number should be easily read, and in order that this may be done, the author has found that three-light incandescent lamps, with reflectors behind the mantles, on fairly low posts answer this purpose admirably. At points where trains are broken up on these sidings, a particularly good light is required, and a minimum illumination of 0.15 foot-candle found none too much. In sidings where neither gas nor electricity is available the Kitson pressure oil-lamp will be found very useful.

Freight Sheds.—Here, even more than on stations, the points available for fixing lights are very confined. It often happens that the jibs of the cranes sweep so close to the roof trusses that the space left between is too small to allow of the fixing of a light, whilst such a position would be a dangerous one for men attending to the lamps when this became necessary. The result is that lights are usually fixed along the stage of a shed, not down the center but staggered on alternate sides so as to miss the swing of the cranes. An ordinary shed consists of stages with cranes, with a cart-way on one side and a siding on the other. The cart-way is often so wide as to require some light down it, and this is provided by a line of lamps placed at sufficient height to prevent damage from high loads. On the stages a good light is essential owing to the necessity of reading quickly and easily labels on goods, written sometimes in all styles of writing with every color of ink. With gas-lighting, groups of two or three incandescent burners in lamps placed from 30 to 40 ft. apart, and from 11 to 13 ft. above the platform, are found to give a satisfactory light, the illumination—neglecting the portion directly under the lamp—varying from 0.9 to 0.25 foot-candle. Where arc-lighting is used in these sheds, the lights are usually placed 45 to 60 ft. apart, and at heights from 13 to 15 ft. above the stage level. The illumination varies from 2.25 foot-candles down to 0.4.

Locomotive Sheds.—The sheds of the Midland Railway Co. are of two types, either round with a turntable in the center and pits radiating from it, or rectangular with an entrance at one end and pits running down the length of the shed. The lighting was formerly carried out by means of star or similar gas-lights with four, six or eight burners, each consuming about 5 cu. ft. per hour. In the case of the round sheds, these lights were placed between every other pit, with the result that one side of each engine was left in darkness. Upon the advent of the incandescent burner these old lights were replaced by two-light incandescent burners, either in lamps or under shades, which were placed between each pit. The result was that not only was a better and more evenly distributed light obtained, but a considerable economy was effected in the cost of lighting. With the rectangular sheds the lights usually required rearranging, and the results, so far as improvement in lighting and economy are concerned, were the same as with the round sheds. The percentage of saving is rather hard to give from actual figures, as the gas consumption in the sheds themselves is not measured, as the gas meters provided also register the gas used in yard, shops, offices, etc. The figures in Table 1, however, may be interesting as showing the economy effected on the whole by the substitution of incandescent burners for some of the flat-flame ones in use. The figures given under C are for two adjacent round sheds, etc., controlled by one meter. Figures under D are for a rectangular shed.

The cost of making the alteration was £376 in case C, and £146 in case D, but it will be seen that these amounts were soon wiped off by the saving effected, even after allowance had been made for the cost of maintaining the incandescent burners.

Lighting of Locomotive Erecting Shops.—In lighting a locomotive erecting shop, certain initial difficulties are met with. These are, the need of a good general well-diffused light, and the fact that, as cranes run down the whole width and length of the shops, the light must be at least 29 ft. above the floor level. The author was met with these difficulties when asked to improve the illumination of a large erecting shop of three bays, each measuring 450 x 50 ft. At first arc-lamps, under large white-washed reflecting boards, were tried above the cranes, but for one reason or another were not wholly satisfactory. These lamps were then superseded by arcs placed between the columns separating the bays, but this did not provide a sufficient light in the center of the shop. About this time a smaller shop was erected at Kentish Town, and the author lighted this by high-pressure gas-burners, placing three of these under a white-washed reflector. The results are very satisfactory, a steady well-diffused light being obtained, whilst the burners have required little attention and the consumption of mantles has been low. In this case, as so small a number of burners are used, water is employed for raising the gas pressure from 1 to 8 in. of water, and as an old-type compressor was fixed, the water-consumption has been somewhat high, being 327 imp. gal. per 1,000 cu. ft. of gas compressed.

The peculiar shaped reflector is used as it is easily fixed between the trusses, and it effectually prevents much light being thrown on the glass roof and lost, as nearly all the rays fall on it or on the portion of the roof that is painted white. The burners are 30 ft. 6 in. from the floor, on which the illumination varies from 0.48 to 0.95 foot-candles.

TABLE 1.—SAVING DUE TO SUBSTITUTION OF INCANDESCENT FOR FLAT BURNERS.

	C.	D.
Flat flame burners dispensed with.........	539	273
Total candle-power of these	5,390	2,730
Incandescent burners fixed	266	141
Total candle-power of these	11,770	6,239
Gas used per annum when flame burners were employed.......	6,947,800 cu. ft.	4,000,500 cu. ft.
Gas used per annum after incandescent burners were employed	4,452,500 cu. ft.	2,354,000 cu. ft.
Percentage increase in candle-power	118%	128%
Percentage decrease in gas-consumption	35.9%	41.16%

Maintenance of Incandescent Burners Per Annum.

	Total.	Per Burner.	Total.	Per Burner.
Mantels	1,692	6.36	1,076	7.63
Chimneys ...	346	1.3	322	2.28
Forks	152	0.57	130	0.92
Wages	£26 0*s.* 0*d.*	1/11.46*d.*	£13 13*s.* 0*d.*	1/11.23*d.*

The success of this lighting led to the same system being adopted at the large shop previously mentioned. In this case the reflectors employed are like the ones at Kentish Town. They are white-washed, and the author has found in practice that this substance has all the properties of a reflector, as claimed for it by Mr. A. P. Trotter in a paper read by him before the Institution of Civil Engineers. The illumination, 29 ft. 8 in. below the burners, varies from 0.8 to 1.4 foot-candles. It is found that the burners only require attention about every 7 to 10 days. In large buildings such as these, where it is impossible to have a light of this description in any position except at a great height above the work, it is not possible to dispense entirely with lights on the benches themselves, but these can be reduced to a minimum, and are only required where a long hole has to be seen through. Even these could be dispensed with if the vises could be fixed opposite a white-washed wall.

The cost of maintenance, in addition to the cost of gas (each burner consumes about 10 cu. ft. per hour), has been as follows for the year to June, 1906: Mantles, 2.85d. per annum; forks, 0.23d.; sundry fittings, etc., 4.55d.; wages, 6.00d. The lights are of course only used during the dark months, or when special work requires carrying out during the night.

Brass Foundry.—The satisfaction given by this lighting and its economy has led to its being adopted in all shops where a good general light is required, such as those in which boilers, tenders, etc., are dealt with. It has even been installed in the brass foundry at Derby, and has been found very satisfactory. The height the burners are fixed above the floor (21 ft. in this case) is apparently sufficient to prevent their being interfered with by the dust, etc., which is always found in such shops.

Fitting Shops.—In fitting and machine shops, although a general light is required, yet particular points require special attention unless the general illumination is very good. The construction of the fitting shop at Horwich has allowed the systematic arrangement of a large number of arc-lamps under white-washed screens, and the author, who has worked both on machines and at the bench in this shop, can testify to the excellent effect given.

In the shops he has had to deal with, the construction has not admitted of the employment of large units of light, as, to use them successfully, they must be placed at a considerable height above the surface to be illuminated. With gas available at a very low cost, extensive use has been made of a two-light incandescent gas fitting under a 28-in. enamelled shade. The use of a smaller unit of light, such as this, allows of a much better illumination when the lights have to be fixed lower down.

In some cases, owing to the provision of cranes, or from other causes, it has been found necessary to provide a special light for a vise. In such positions a single light with a special antivibrator support has proved useful. These have also been employed to light a row of lathes fixed against a wall, and where it was not thought advisable to provide large units of light high up. In these circumstances they are fixed behind the lathe.

Iron Foundry.—The lighting of iron foundries seems to be one particularly suited to arc-lamps, but the author, from his experience with high-pressure gas-lights in the brass foundry referred to, believes that this system of gas-lighting may successfully be employed in illuminating what is usually the one dark spot about a works. At Derby the side of the foundry on which light work is carried out, and along which no crane runs, has been lighted for some time with ordinary incandescent gas-burners. On the section where a crane is necessary to deal with heavy castings, etc., high-pressure gas-lights under white-washed reflectors have been installed. In this connection it may not be out of place here to refer to the very strong influence of dark walls, floor, etc., and the floor of a foundry is never in any sense a reflector, whilst the dust which settles on, at all events, the lower parts of the walls prevents them doing their part in the general illumination. The question of the color of surroundings on lighting effect, although often referred to, is too often neglected. In some figures given in a short paper read by the author before the Manchester District Institution of Gas Engineers, he showed that this in practice may add about 20 per cent. to the actual illumination.

In conclusion the author points out that if he has seemed to deal with the question of gas-lighting somewhat to the exclusion of other types, it is because he has of necessity had to speak of the lighting that he has had most to do with.

THE DEATH ROLL from tunneling operations in New York City during 1906 was 68, according to a report issued by the coroners. The Pennsylvania tunnels are charged with 12 deaths from the bends, 29 due to accidents and explosions and two from drowning during the flooding of submerged tunnels. In the Belmont tunnel there were seven deaths from the bends, 9 from accidents and similar causes and four by drowning. The Battery tunnel had but two deaths charged against it, one from the bends and the other from an accident. In the work at Church and Dey Sts. there were three deaths, all due to the bends. If anybody thinks that caisson disease is a great rarity among tunnel workers it is only necessary to observe that one-third of the fatalities reported by the coroners were due to the bends.

Letters to the Editor.

Reinforced Concrete Beams.

Sir.—Referring to Mr. E. P. Goodrich's letter in your issue of Dec. 26, 1906, relative to the writer's letter in your issue of Dec. 1, about reinforced concrete beams: "p/t = percentage of steel in terms of concrete in compression" is a correct equation, because p and t are fixed unit stresses in the concrete and the steel respectively, and they necessarily fix the proportion between the total area of concrete in compression, and the total area of the steel in tension. Consequently, they also establish the equality between total compression and total tension, bearing in mind that p is the mean pressure per square inch above the neutral axis.

This is also the basis of the equation, $a = m \div t\ (d - x/3)$ = area of concrete in compression multiplied by p/t, in which the symbols have the significance specified in the communication of Dec. 1, above mentioned.

Regarding different factors of safety: if concrete could be manufactured with the same certainty as to its strength and behavior under stress as obtains in making steel, there would be no reason to protect it with a factor greater than for steel.

Doubtless Mr. Goodrich figures a factor of safety of about 2½ for the steel on the basis of taking an elastic limit of 30,000 to 40,000 lb. for the steel, as the point beyond which the unbalancing of the assumed conditions of action in the concrete and steel will cause failure in the former.

In this discussion, the writer has assumed the ultimate strength of 1:2:4 concrete to be 2,400 lb. per square inch in compression with a maximum working stress of 600 lb., giving a factor of 4 for safety, which is, of course, the same as for steel having an ultimate strength of 64,000 lb. and a working stress of 16,000 lb., or 48,000 and 12,000 lb., respectively.

Regarding the lower working stress for plain round bars, this is advisable primarily because such bars are usually bought out of stock and their elastic limit and ultimate strength are quite likely to be lower than the same factors in the deformed bars made especially for reinforced concrete work. Moreover, whatever theoretical deductions may establish, the fact remains that the deformed bars have the additional mechanical bond not possessed by the plain bars, except in so far as the physical character of the surface of the latter may afford some mechanical union.

The writer does not believe that the use of smooth bars is ever justified on the basis of efficiency of the union with the concrete under a given stress. The greater facility with which plain bars can be delivered by all dealers and their lower cost per pound very frequently make them the proper kind to use. Plain bars require great care for protection against disturbance while the concrete is setting around them, otherwise, the adhesive bond will be broken in whole or in part. With deformed bars, the mechanical bond would still remain, and would be sufficient to take care of the stresses if properly designed.

It has been the experience of the writer that plain bars, especially small round ones, which project from unfinished work during construction, are frequently disturbed by the progress of the work while the concrete is setting, and the adhesion very materially, if not entirely, destroyed. While this is not an argument against the efficiency of plain bars per se under perfect conditions of construction, judicious selection of materials depends largely on the things that may or will happen in the construction.

The writer believes that web reinforcement to take care of one-half the shear is sufficient, because all experiments indicate that a beam without web reinforcement is amply strong to resist at least half of the shear produced by the breaking load on the beam when fully reinforced against shear. Theoretically, economical reinforcement of this kind should start with 50 per cent of the shear at the end reaction and decrease toward the center, as the shear decreases, providing, however, that an arbitrary minimum reinforcement be continued to the middle of the beam, for the reason stated in the original communication above mentioned.

It may be that, in practice, Mr. Goodrich's plan of varying the spacing rather than the size of the shear rods, would work out most economically. Both methods would be equally rational. It will generally be found that one can be very liberal in the amount of web reinforcement without materially increasing the cost of the work as a whole.

In the case of extremely short and heavily loaded beams mentioned by Mr. Goodrich, it appears to the writer that it is then a question of shear at the end reaction rather than of a beam designed to resist a bending moment; i. e., the sectional area of the concrete will be determined by the amount of the vertical shear produced by the end reaction on the line of the face of the abutment, in which case, the formula in question would not apply to such conditions.

Yours truly, J. L. Campbell.

El Paso, Jan. 3.

Reservoir Troubles.

Sir: In the abstract of the report by Messrs. Allen Hazen and George W. Fuller, on the advisability of stripping the Ashokan reservoir, printed in the Record of Jan. 5, reference was made to the influence of seeding on reservoir troubles. Will you please give the full text of this part of the report.

Yours truly, Reader.

New York, Jan. 8.

[The two sections of the report bearing directly on this subject read as follows:

Seeding.—Troubles arise from growths of organisms in reservoir water only when the water is seeded or infected with the organisms. This is a difficult element to take fully into account, as there are cases where reservoirs have been used for years with satisfactory results, after which, without warning, objectionable growths of organisms have started. It is obviously possible and easy to confuse the absence of seeding and the absence of conditions favoring growths in seeking the true reason for freedom from objectionable growths in ponds, lakes and reservoirs.

There is not a great deal of definite information available as to how reservoirs become seeded. Sometimes the spores of organisms are brought into a reservoir by the water coming from the watershed. In other cases the spores seem to be transferred by the wind from swampy places in the general neighborhood. There seems to be no way of keeping the germs or seeds of organisms out of a reservoir; and, although the absence of seeding appears to have been an important element in some phenomena which have been observed and which are otherwise difficult of explanation, it must be assumed that in every case a reservoir may sooner or later become seeded with objectionable vegetable or animal growths.

Among the best illustrations as to the freedom from growths of organisms through absence of seeding are those to be found in numerous ponds and lakes in the South, some of which are used as sources of water supply, and where all other conditions seem to favor abundant growths of organisms.

It may be that there is some antagonism exerted by some groups of organisms which prevents the growth of other groups. We simply mention this point as a possibility. We have obtained no evidence which enables us to discuss it even in general terms.

Other illustrations of the irregularity of organic growths in surface waters are to be found in many of the large natural ponds and lakes throughout the North and including coves and arms of some very large lakes.

The development of water filtration in this country has also furnished illustrations as to the irregularity of organic growths in uncovered filtered water reservoirs. We have examined all available experiences in this regard and find that the results are conspicuous by the absence of growths under conditions where we would certainly expect them if the water was seeded. The list of such filtered water reservoirs, where the clear filtered water more or less resembles ground water, included experiences obtained both with sand filtres and mechanical filters. Among such reservoirs we may mention the distributing reservoirs at Paterson, N. J., and Watertown, N. Y.

Temporary Growths.—Recent information tends strongly to show that growths which would be objectionable in a public water supply are far more frequent in natural ponds and lakes than was formerly supposed. Such growths frequently are of short duration and casual examinations do not reveal their existence. For this reason less importance is to be attached to the supposed favorable conditions in lakes having clean and sandy bottoms than was formerly believed to be the case. In fact, we know of several cases where very deep natural lakes with clean bottoms such as Lake Champlain, have developed vegetable growths in the upper layers of water.

It is also a fact that objectionable growths are frequently of an intense character for a short time and then disappear quite suddenly and leave the water in a satisfactory condition. This, of course, has much significance where the water requires a considerable period for its passage from a storage reservoir through a distributing reservoir to the consumer. It is believed that growths in some quite clean storage reservoirs have in this way escaped detection by the water consumers.

Another factor bearing upon our knowledge as to growths of organisms in reservoirs is that the results of analyses made at intervals sometimes fail entirely to show the presence of objectionable conditions. Even where the analyses are made at intervals of about one each month, as in Massachusetts, it has been found in a number of instances that the reports from the laboratory do not correctly portray the conditions existing at the reservoir. Actual experience at Springfield and Holyoke, Mass., and elsewhere has still further shown that the agitation and aeration of samples of water during transportation to the laboratory frequently minimizes the apparent amount, intensity and effect of growths of organisms.

Taking all of these elements together it is certain that more growths of organisms and more objectionable results therefrom at the source have resulted in reservoirs and natural lakes with comparatively clean sides and bottoms than was formerly supposed to be the case.]

A 1,100-ft. Head has been utilized in a new hydro-electric plant on the Siagne River, a stream of the Maritime Alps in Southern France. Pelton wheels are used to develop 4,500 kw. and are supplied by penstocks brought down to the station almost vertically for a distance of over 3,000 ft. For assistance in speed regulation, 4-ton flywheels are mounted on the generator shafts. Power is transmitted at 11,000 volts, but a 30,000-volt transmission line is now in course of construction to **Marseilles**, a distance of nearly 100 miles.